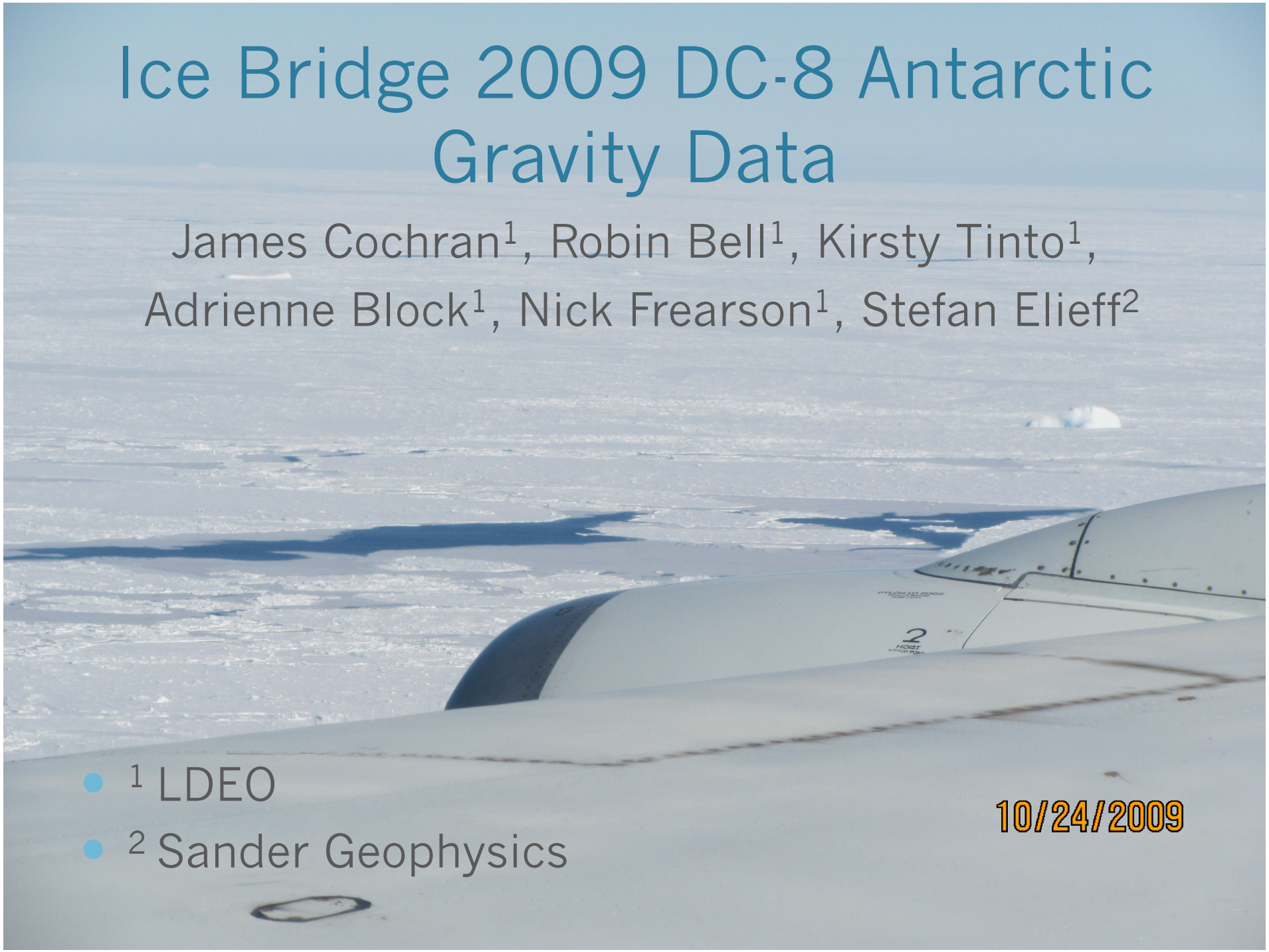
Ice Bridge 2009 DC-8 Antarctic Gravity Data

James Cochran[1], Robin Bell[1], Kirsty Tinto[1], Adrienne Block[1], Nick Frearson[1], Stefan Elieff[2]



- [1] LDEO
- [2] Sander Geophysics

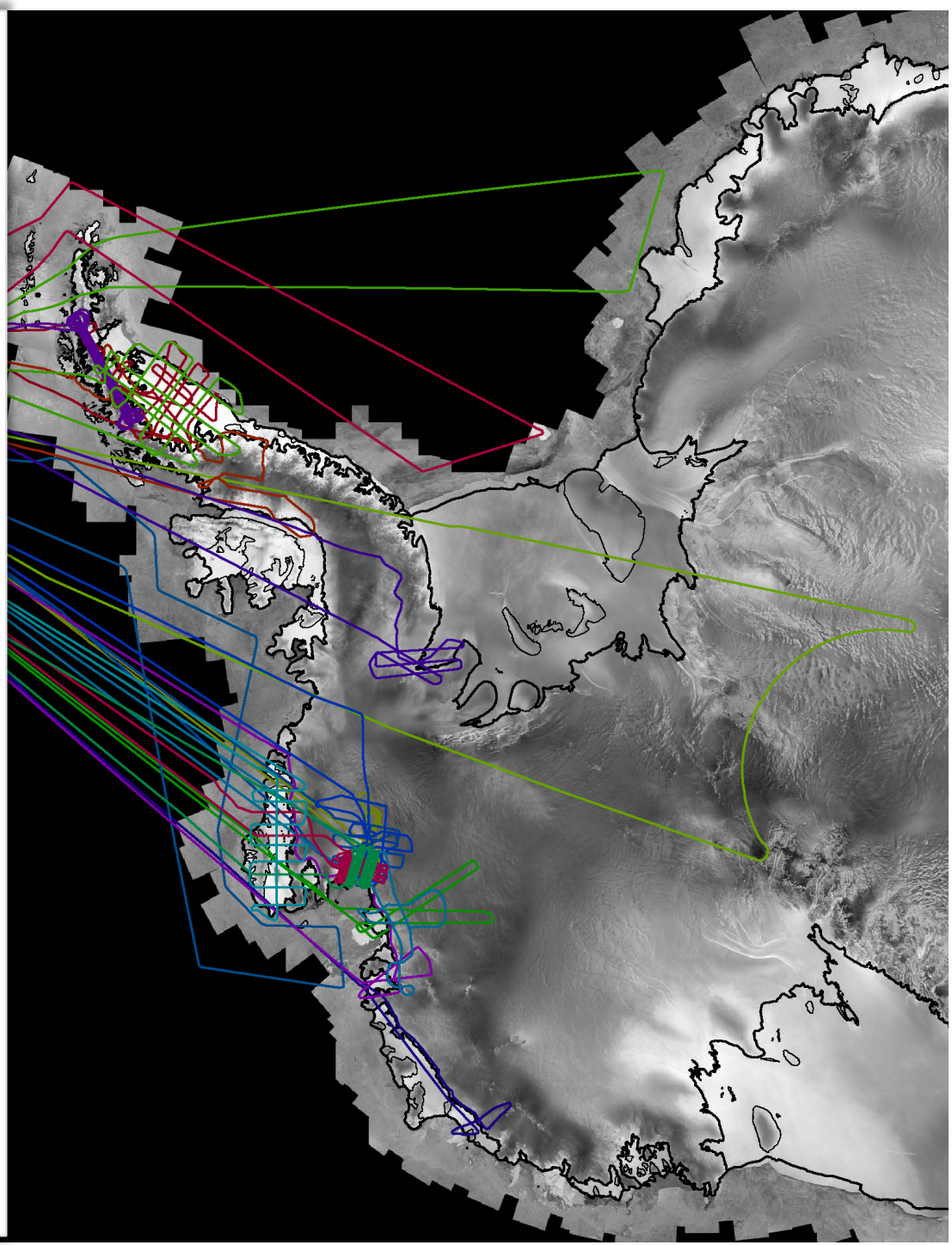
Value of Gravity Measurements

- 1) Determination of sub-ice bed relief
  - Where there is water beneath the ice
    - Allows estimation of cavity below ice
    - Important for models of ice thinning
  - Where environmental conditions degrade radar data
    - Heavily fractured/crevassed or warm ice
- 2) Determination of sea ice freeboard
  - Establish short wavelength undulations in sea level (geoid) in regions of sparse leads

Gravity Data collected on 20 flights

All but Flight 13

Data has been processed and is available from NSIDC



Data Processing

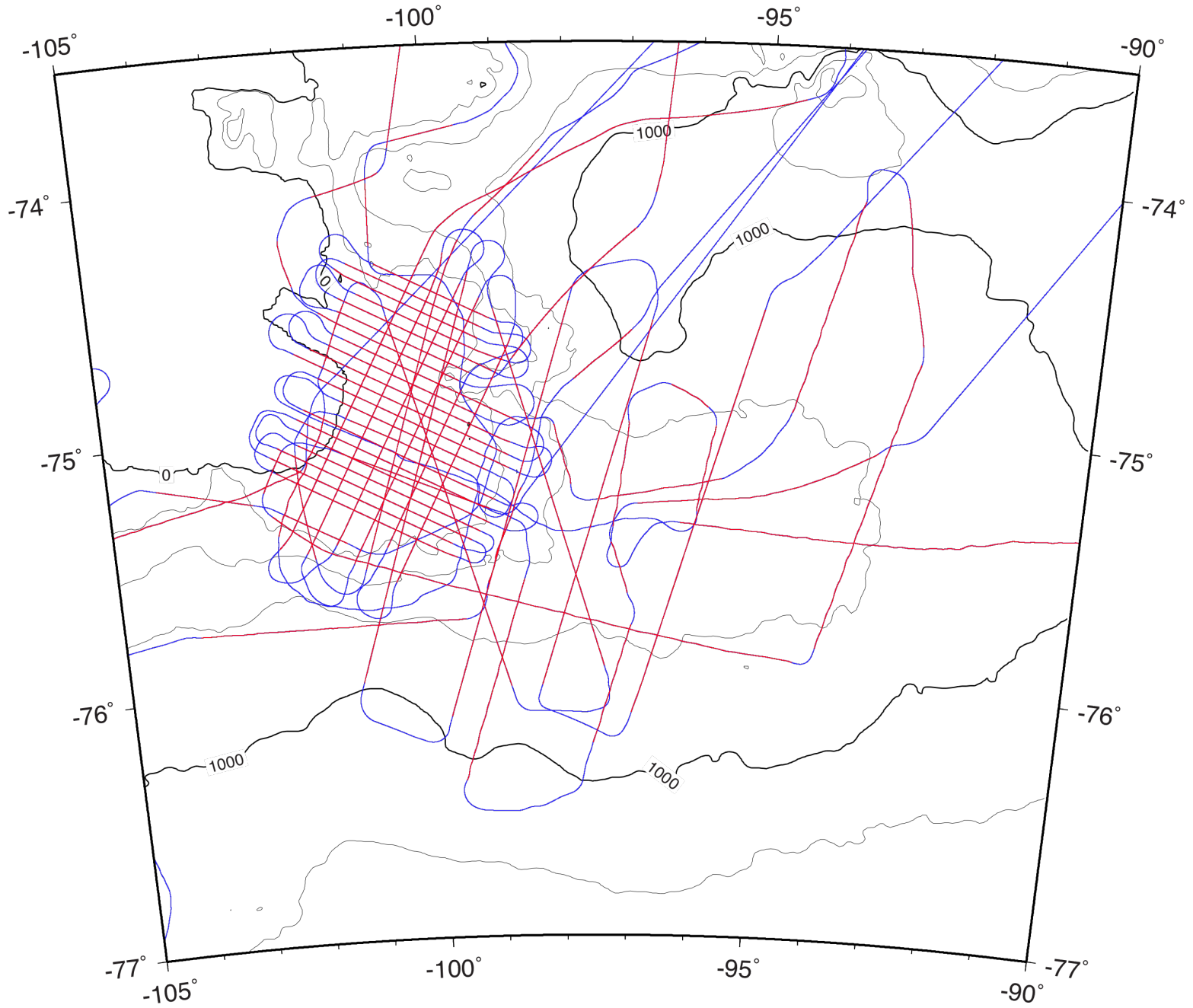
- Data (128 Hz) filtered and decimated to match GPS (10 Hz)
- Remove plane accelerations using DGPS
- Eötvos Correction
  - Measurements are made on a moving platform
- Subtract expected gravity for measurement latitude
- Free-air Correction
  - Correct for height above ellipsoid

Data Resolution and Consistency

- Final track line data given with three different filter lengths (70 sec, 100 sec, 140 sec)
  - User can choose balance of resolution against noise level
- Crossovers (100 sec data) < 1 mGal

Factors affecting Data Quality

- Resolution Issues
  - Aircraft Speed
    - Filtering is in time, not in space
  - Elevation
    - $1/r^2$ is real
    - Short wavelengths attenuate faster, so lose resolution
  - Line Spacing
    - Cross track resolution limited by line spacing
- Plane Maneuvers
  - Strength of AIRGrav system is that can deal with elevation changes (draped lines)
  - Turns introduce accelerations that appear in gravity values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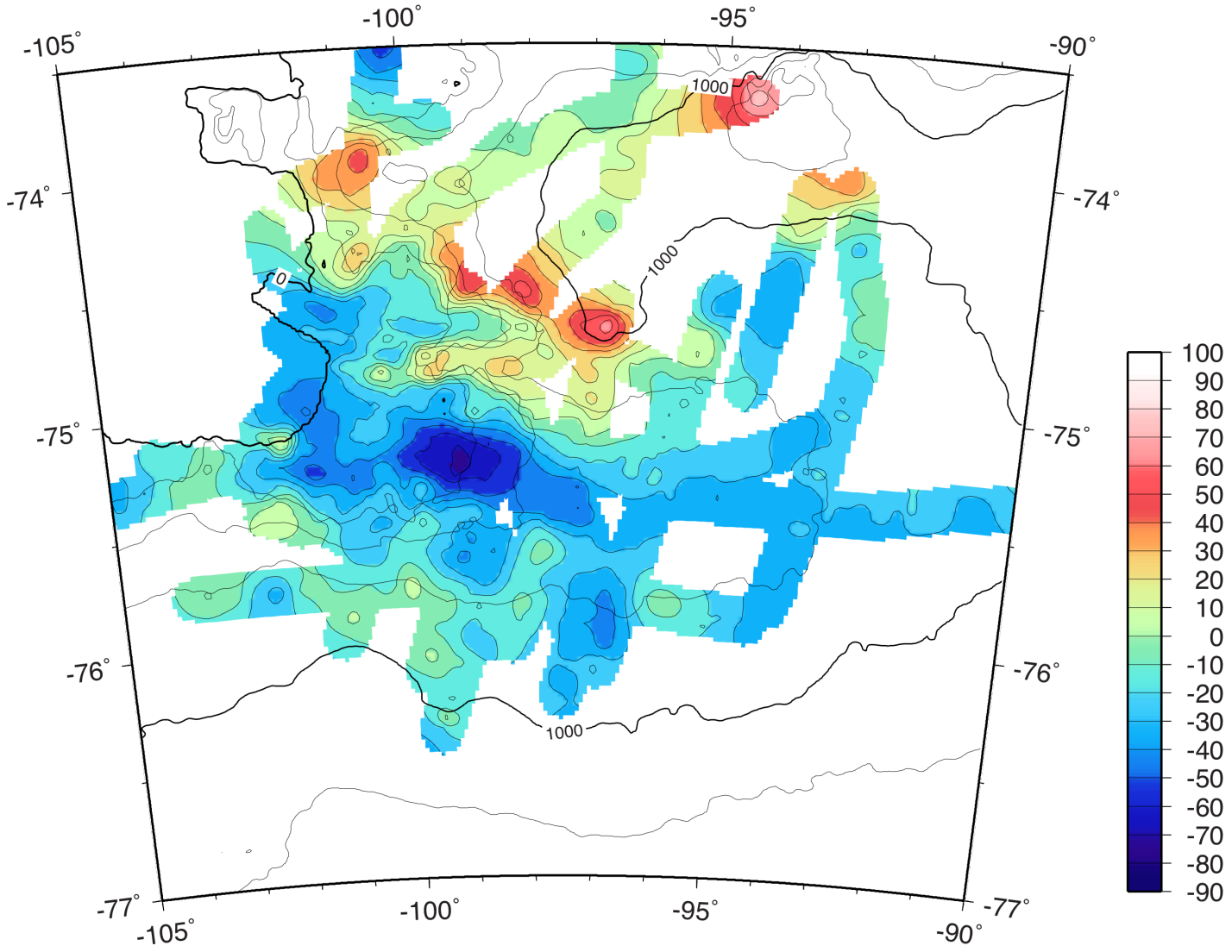
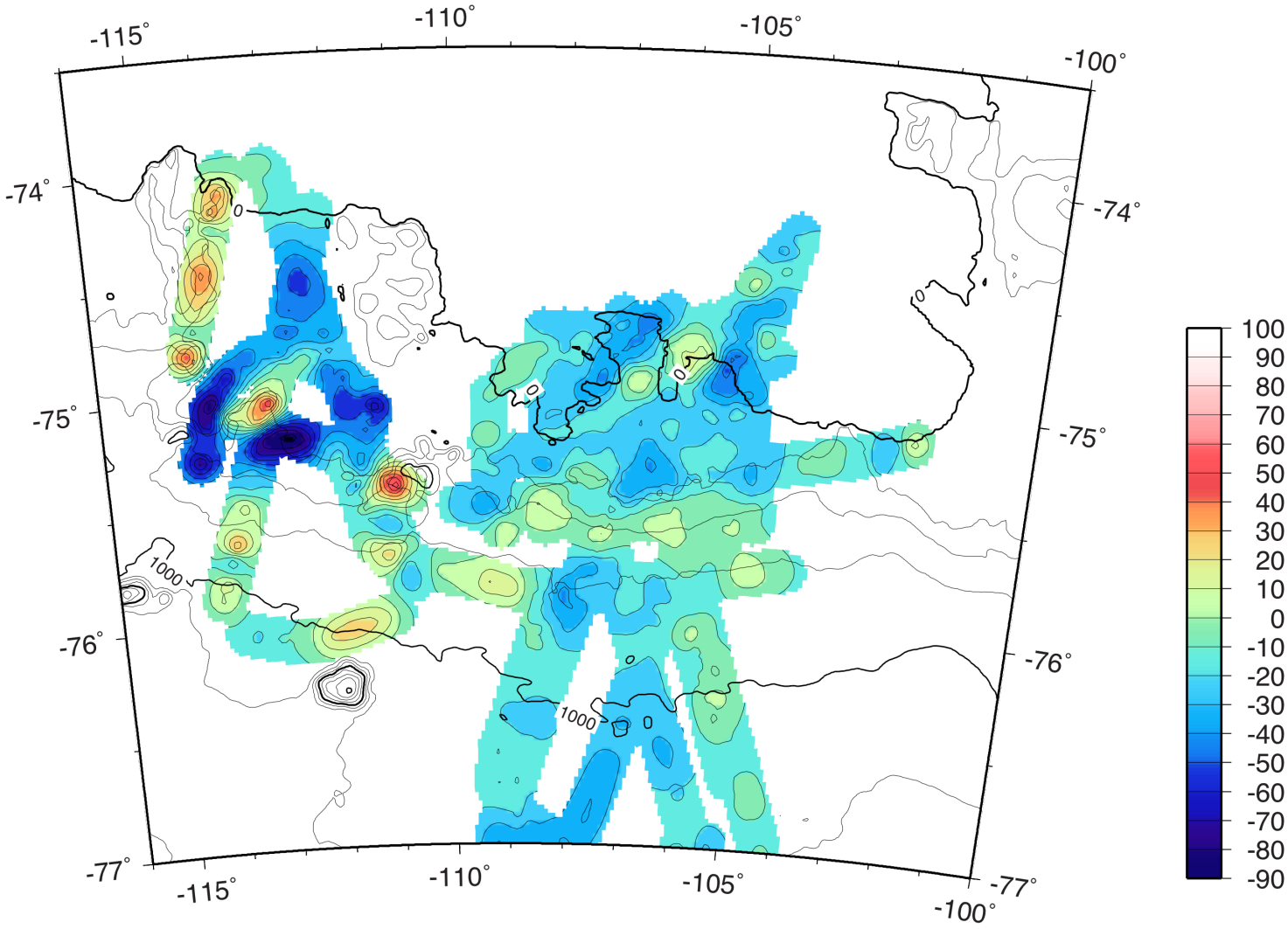
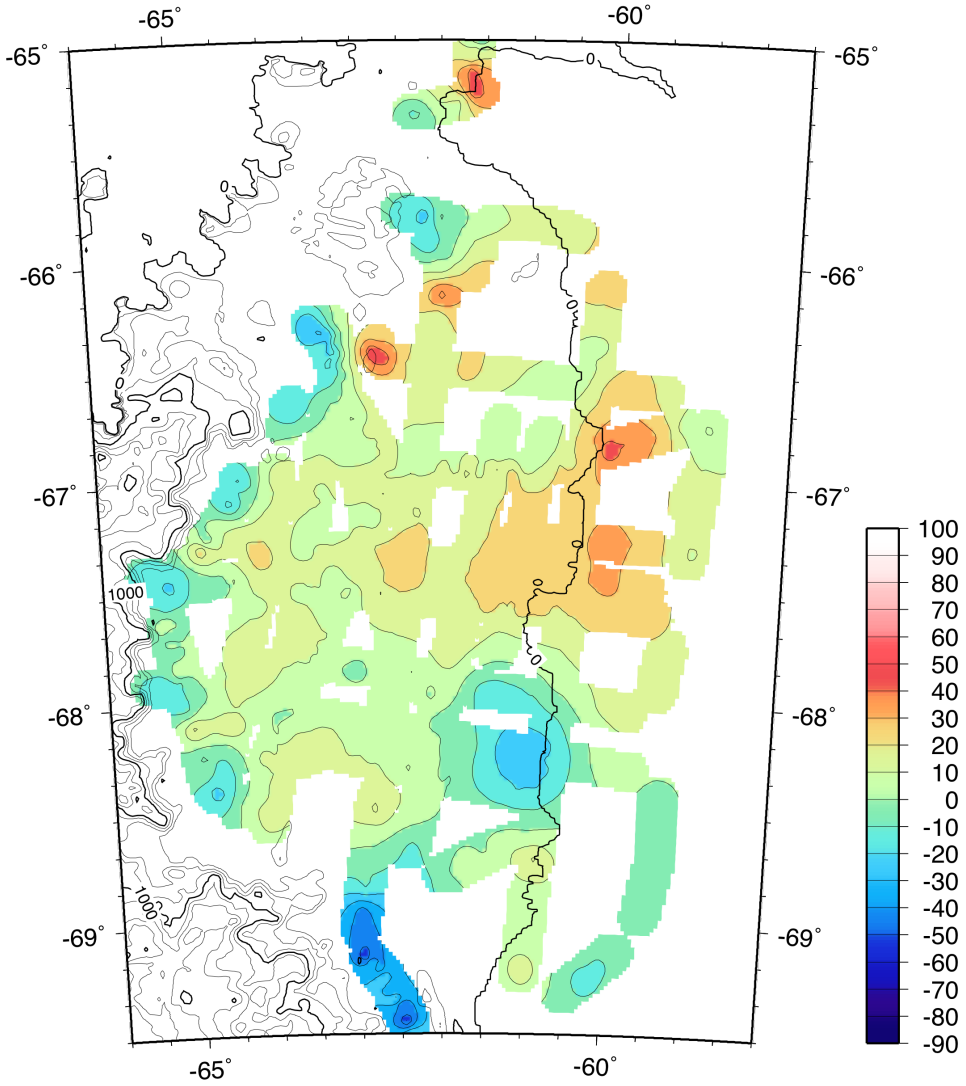
Pine Island Glacier



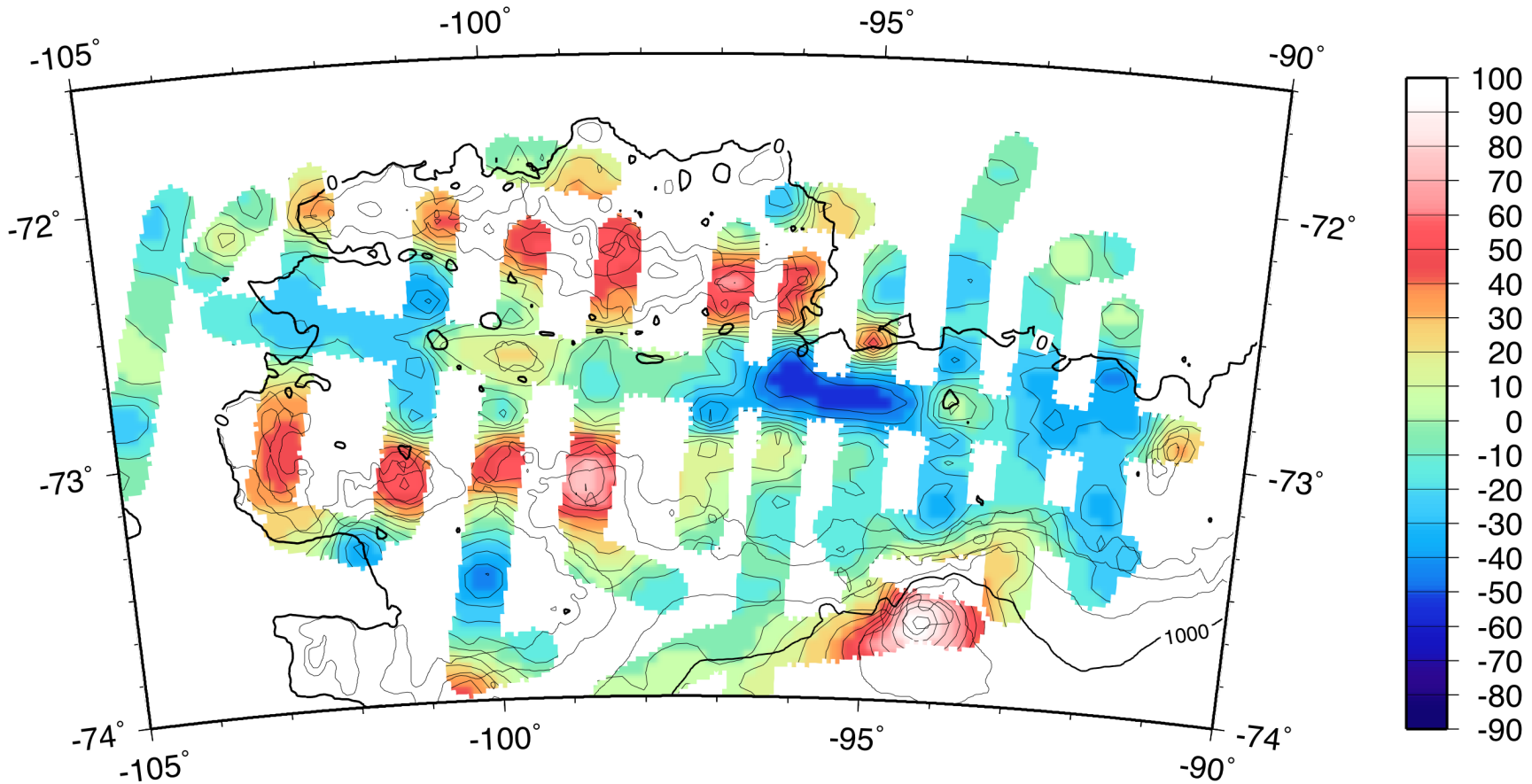
Thwaites and Smith Glaciers



Larsen Ice Shelf



Abbott Ice Shelf



Sea Ice Freeboard

Traditional gravimetric geoid techniques

- Increase density of gravity data used in geoid determination
- Add data in areas of interest

Direct Determination of Deflection of Vertical

- AIRGrav system obtains 3-component accelerations
- We are working with Sander Geophysics on assessing ability to determine Deflection of Vertical.

Sub-Ice Bed Relief

Lessons learned

- Geology matters
- Good surface elevation data matters
- Most efficient technique is inversion combined with forward modeling

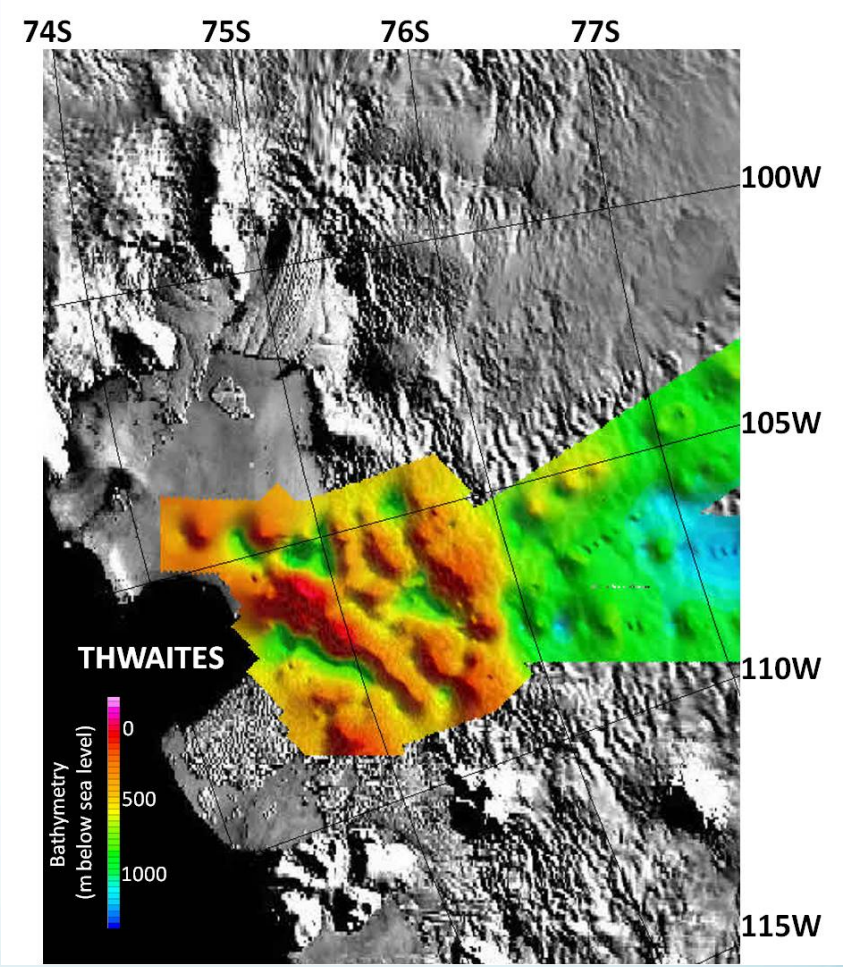
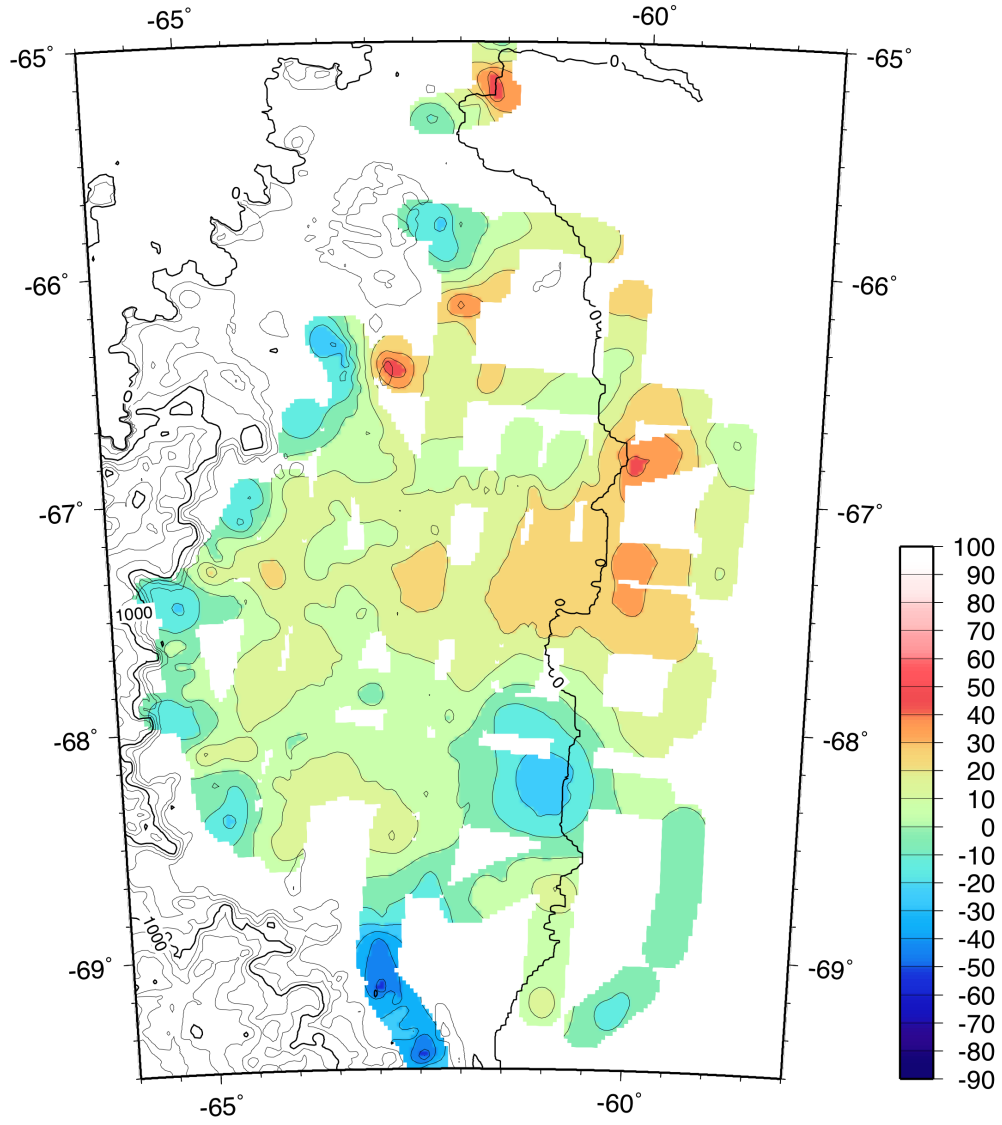
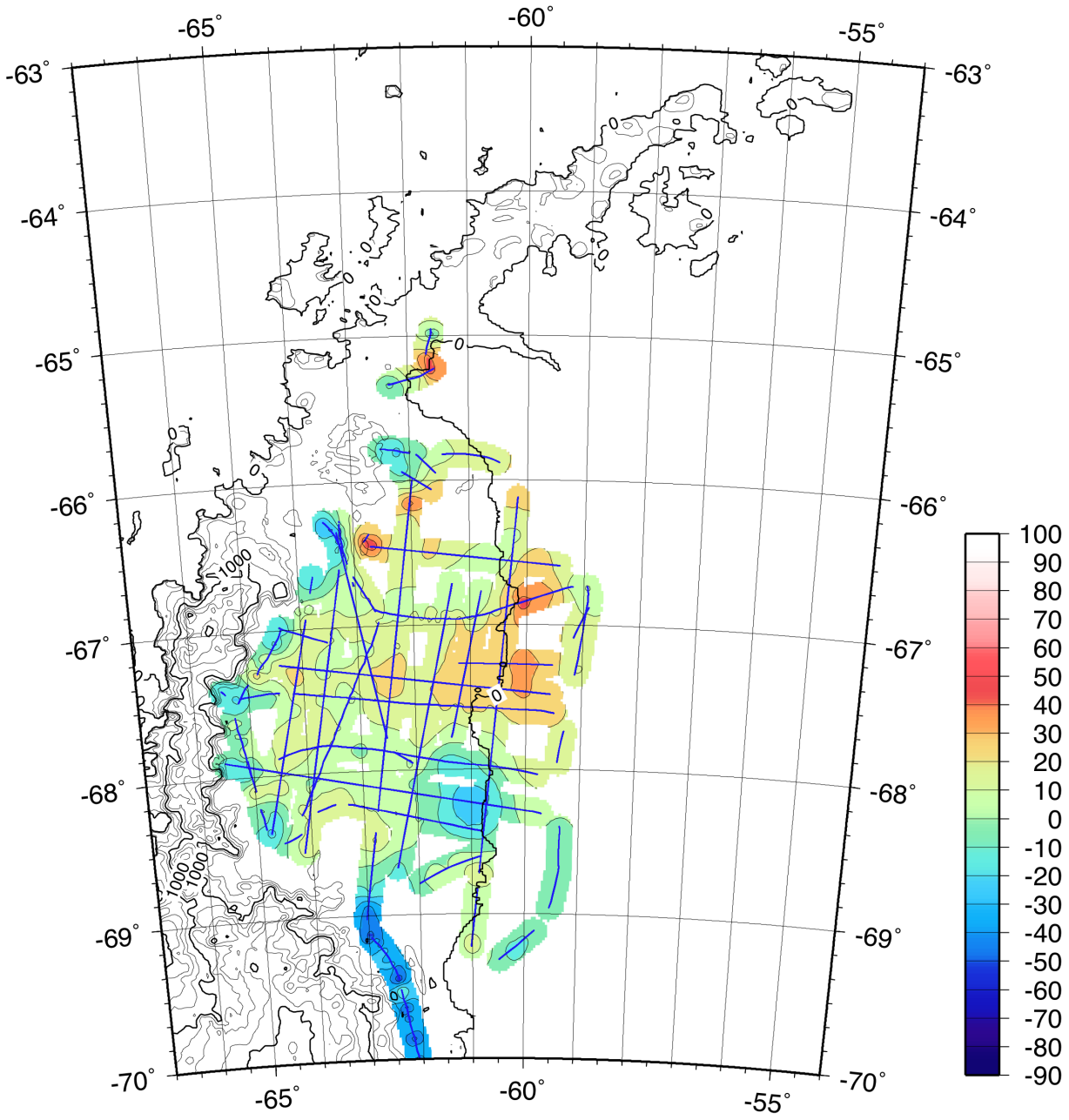


Figure from Kirsty Tinto

Larsen Ice Shelf

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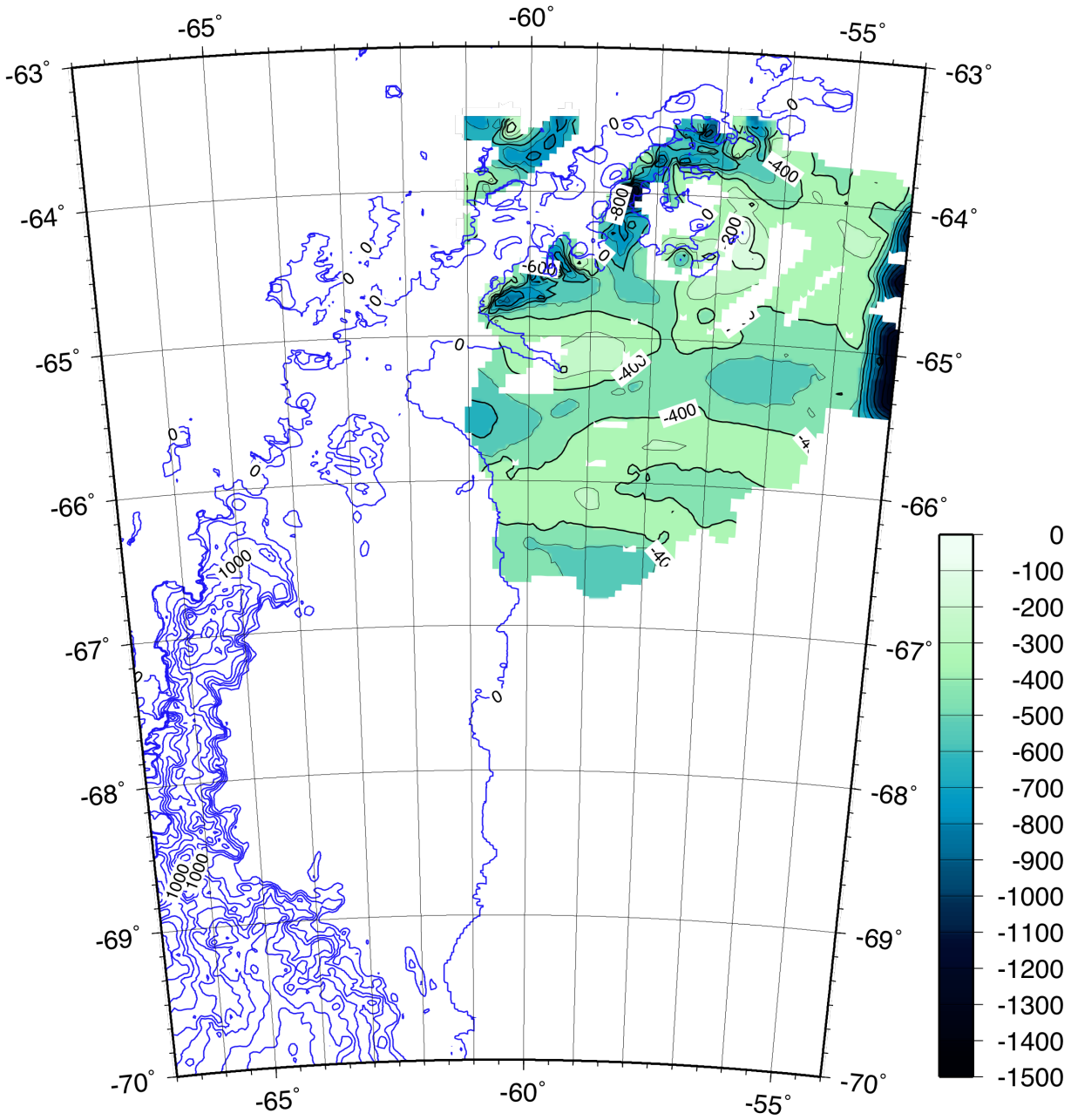
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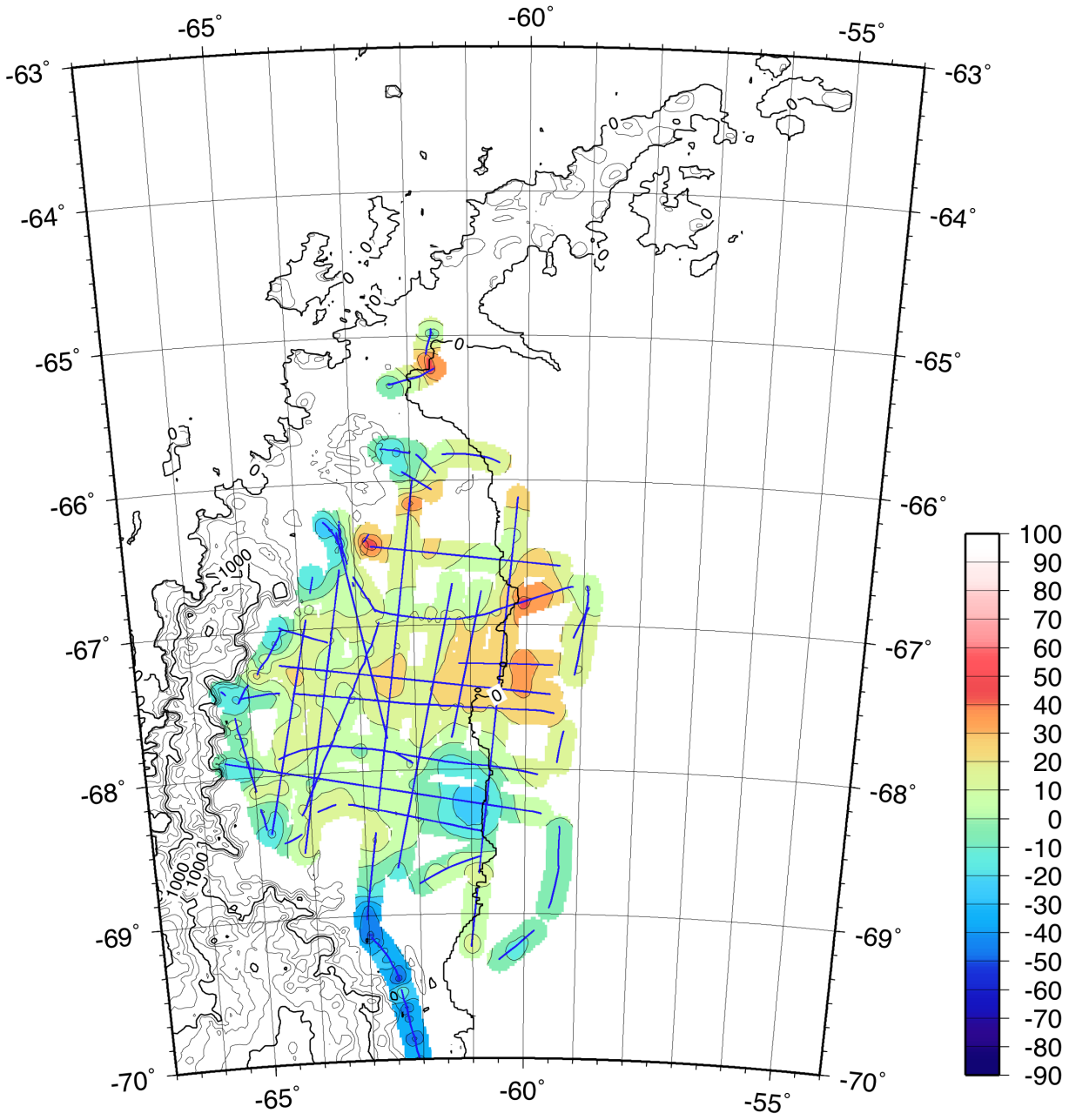
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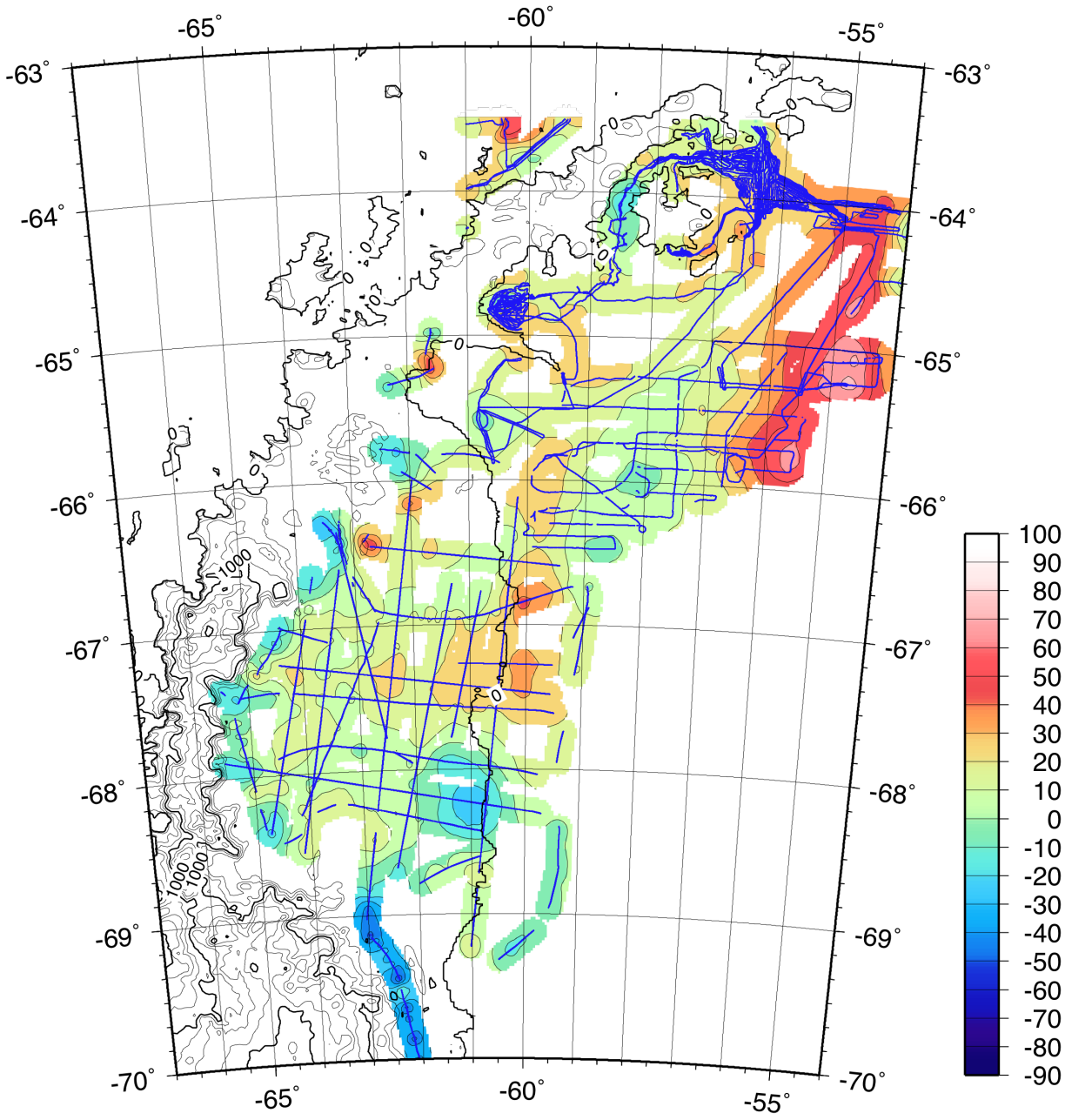
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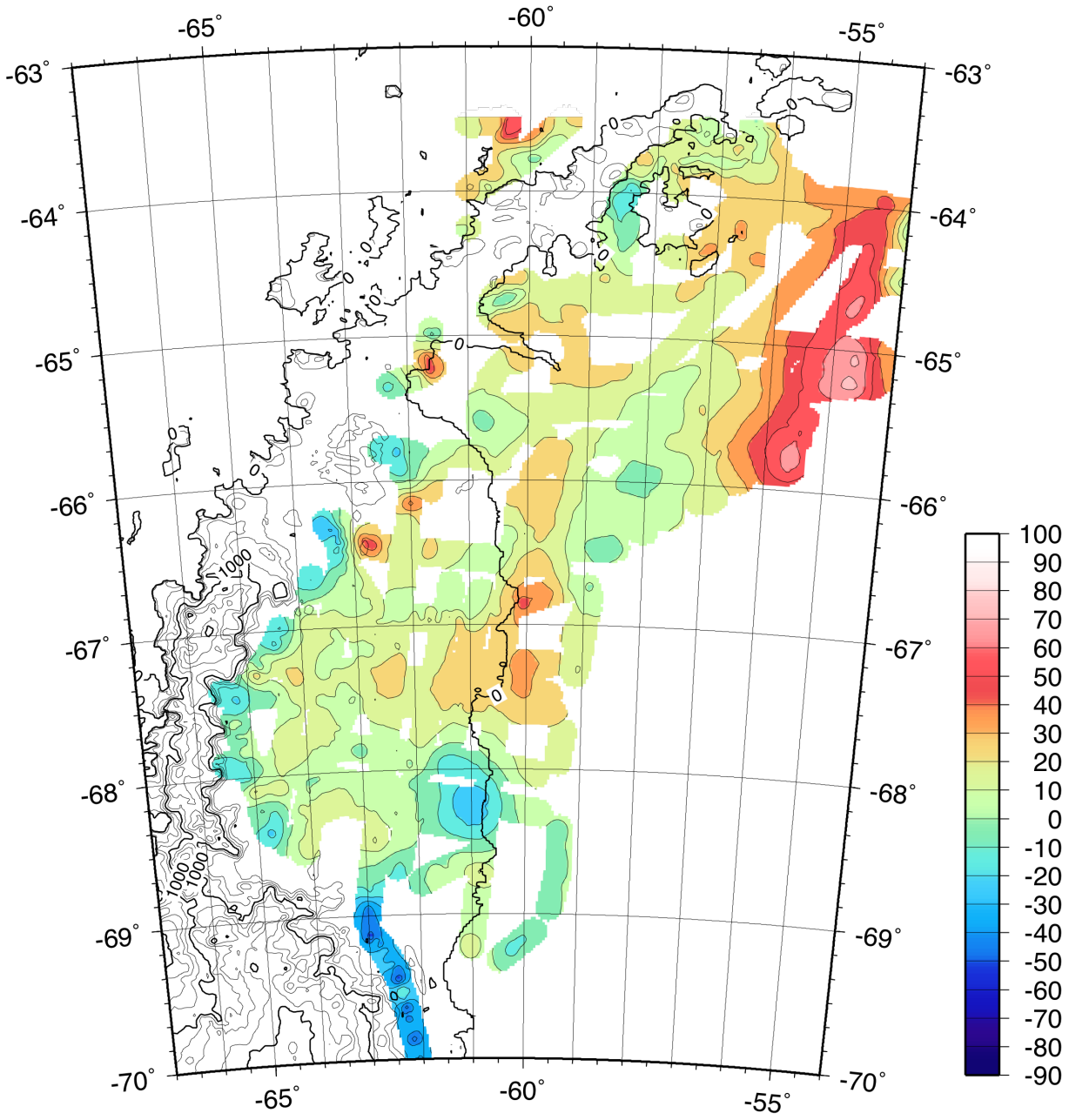
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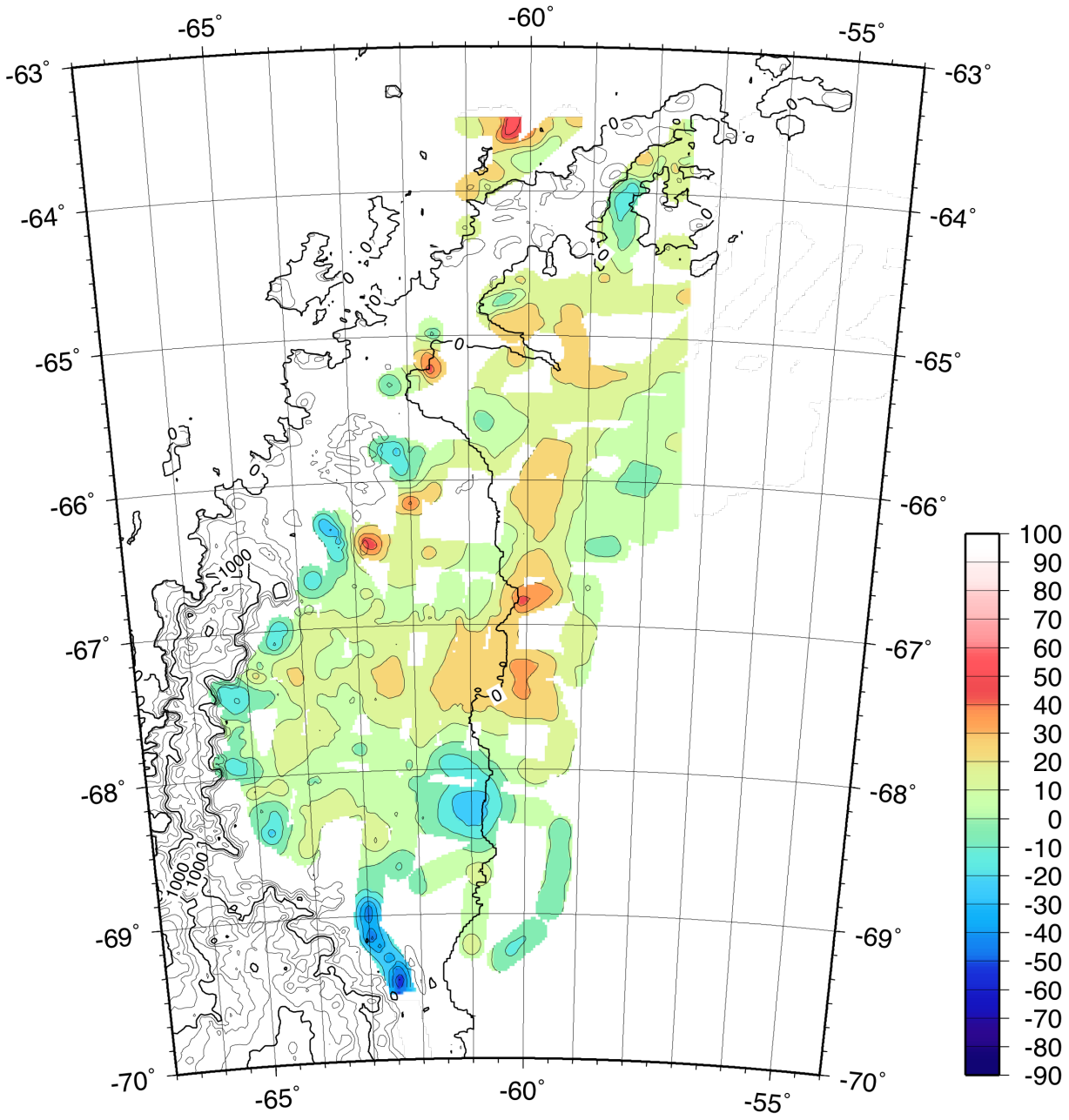
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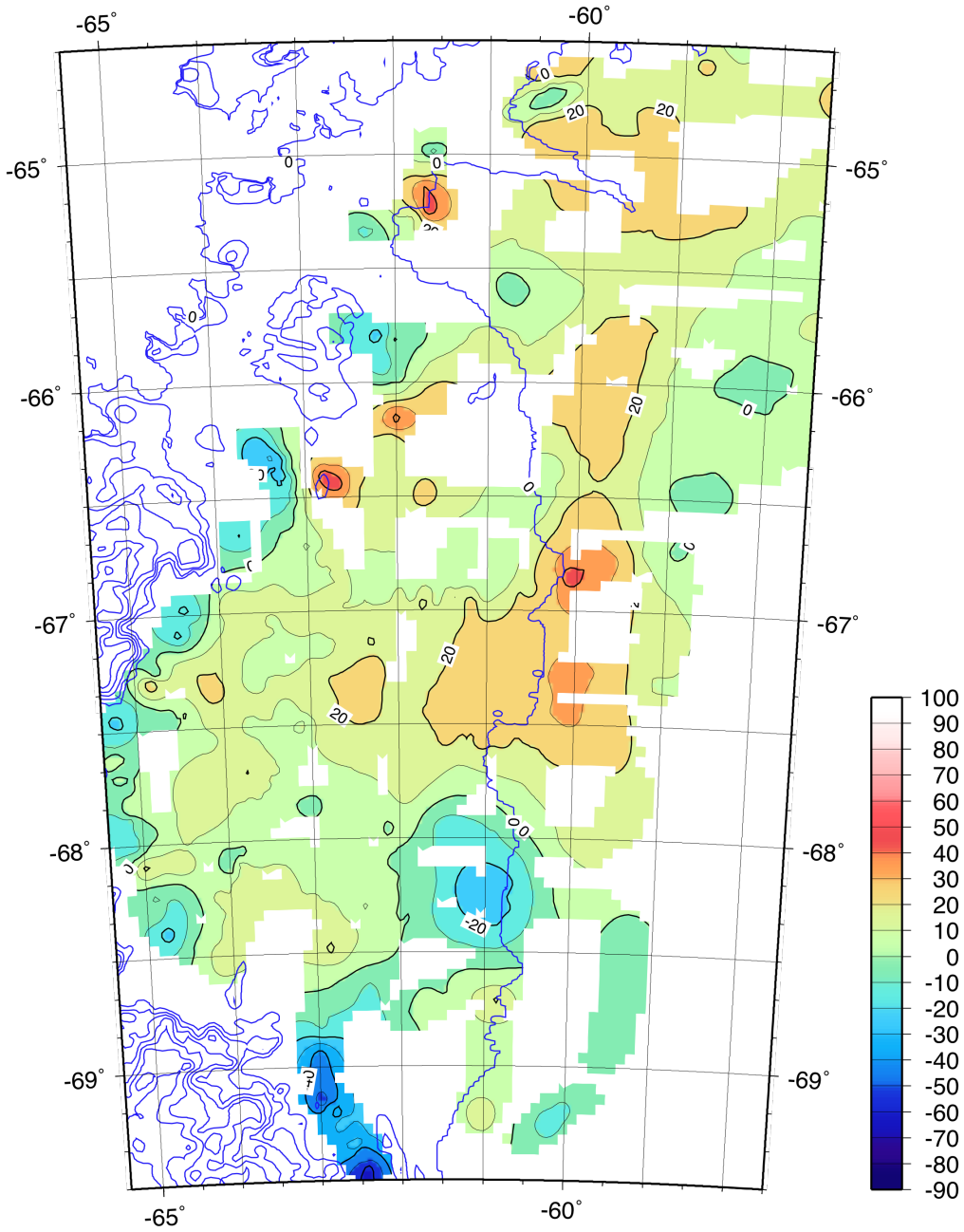
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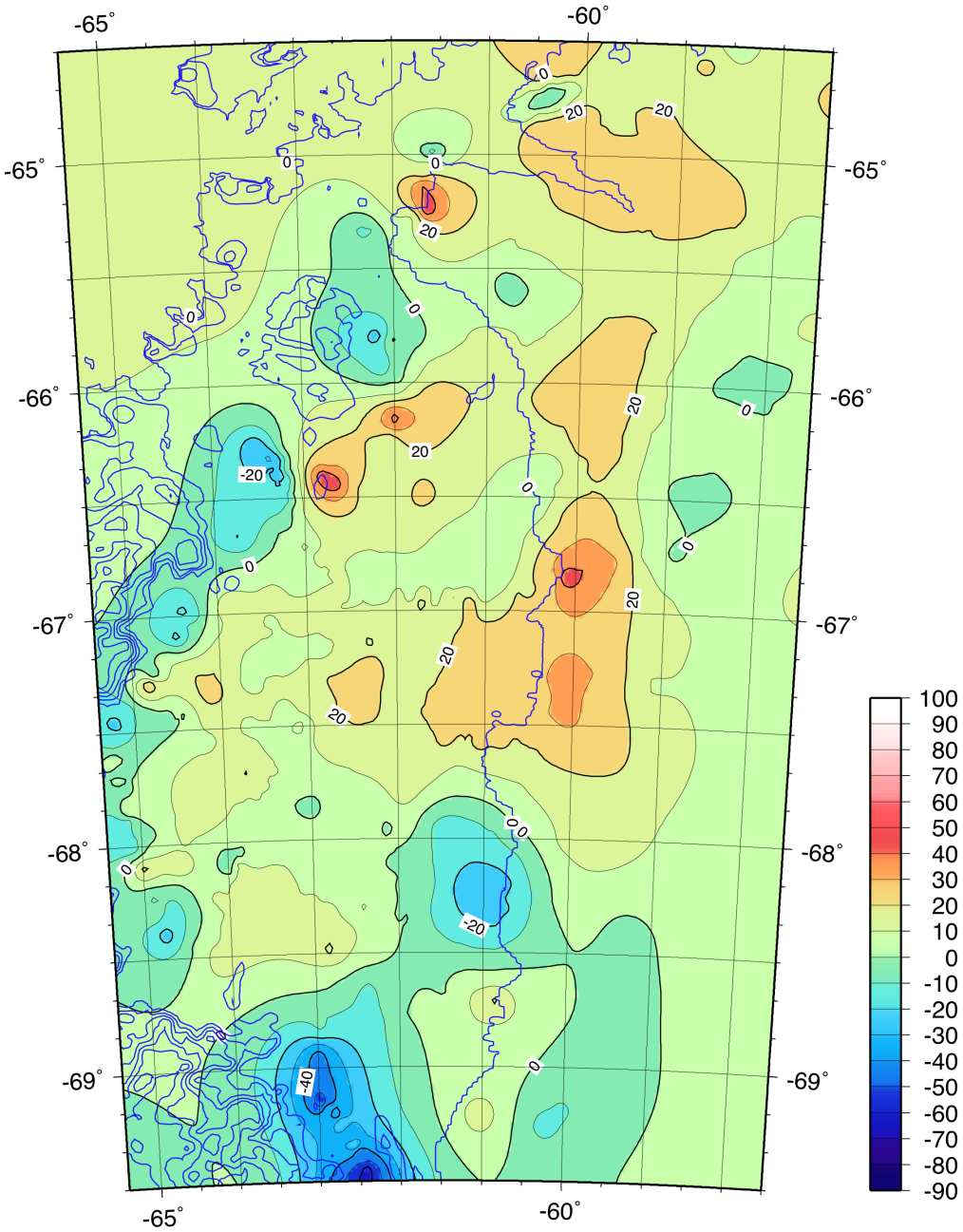
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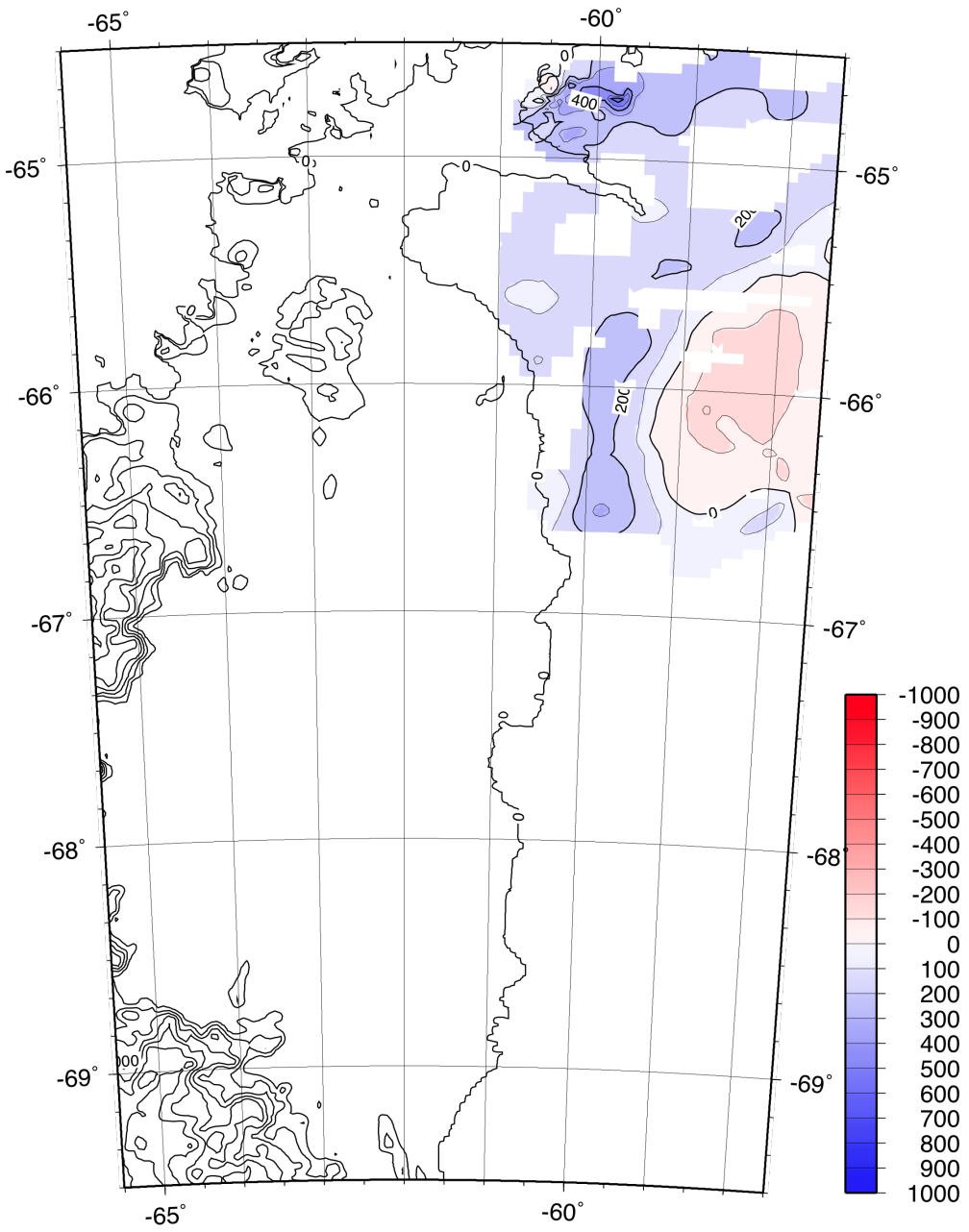
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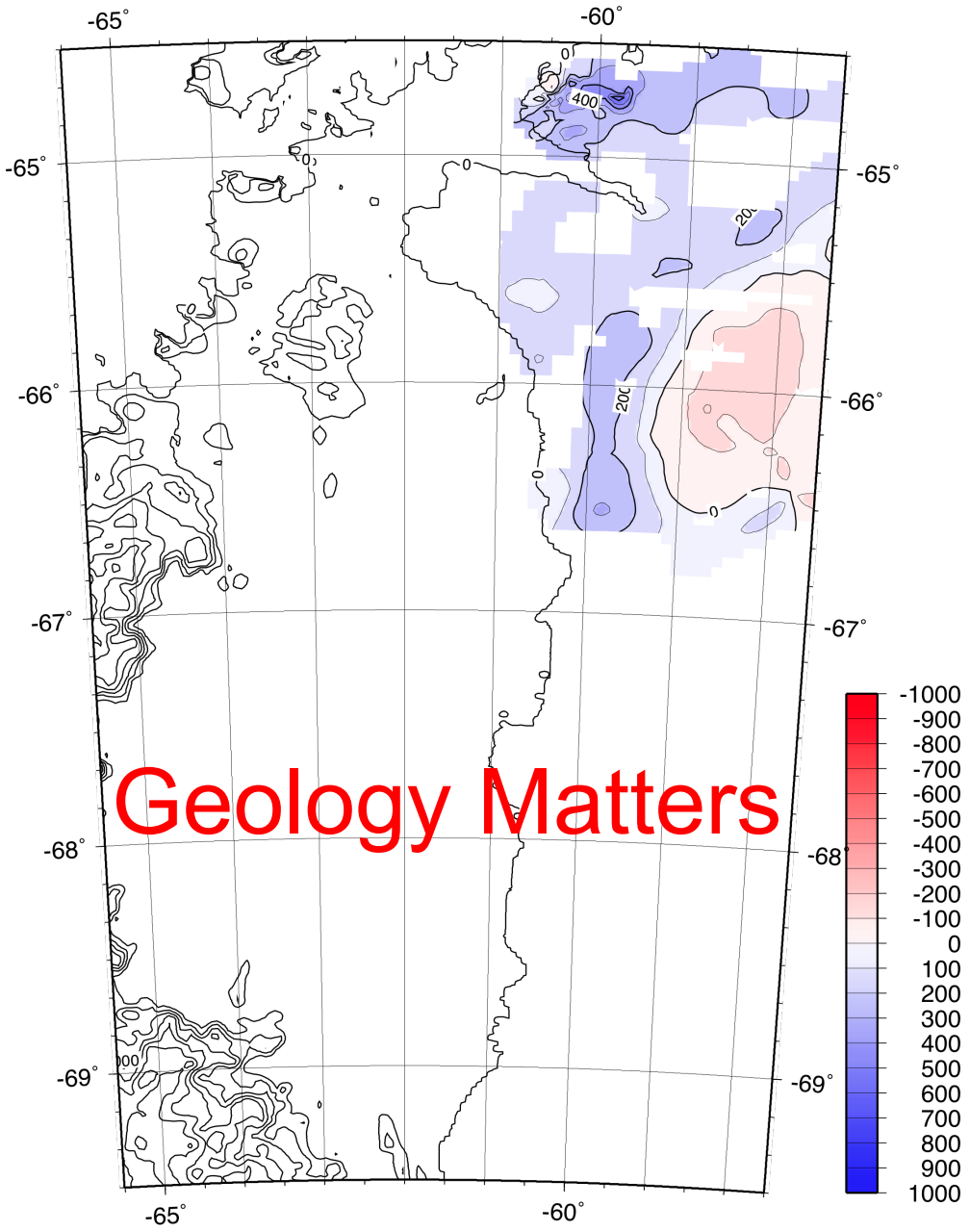
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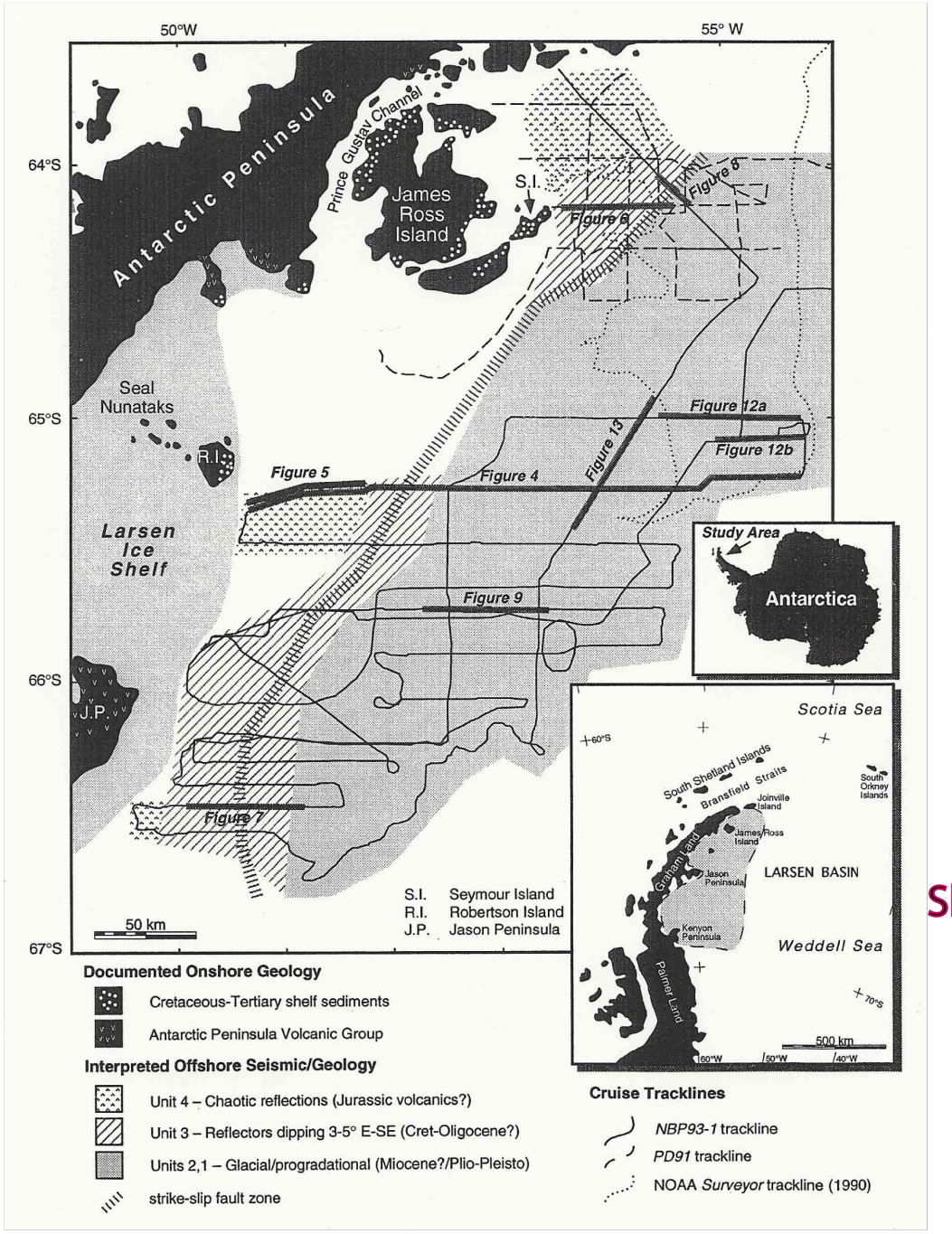
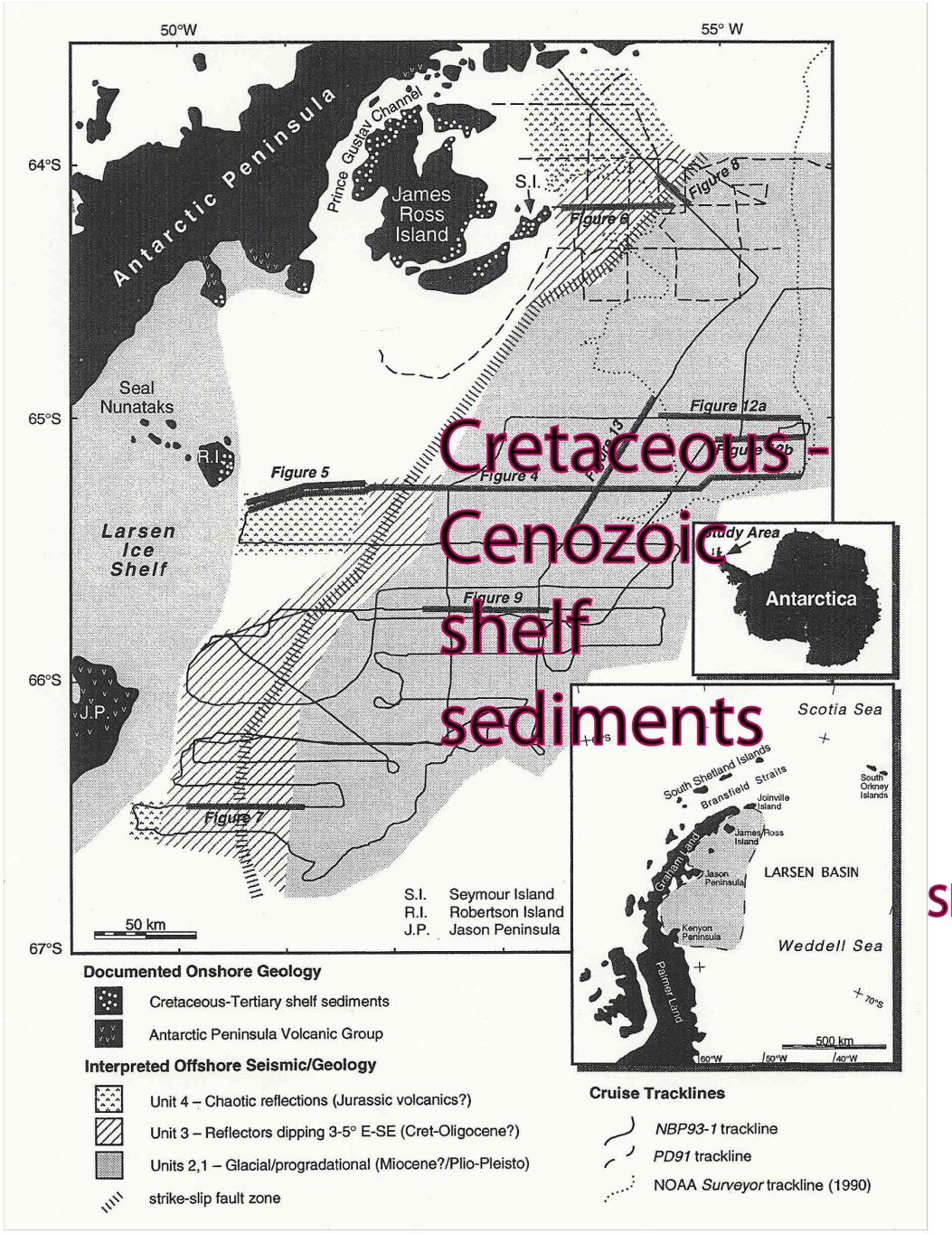
Geology Matters

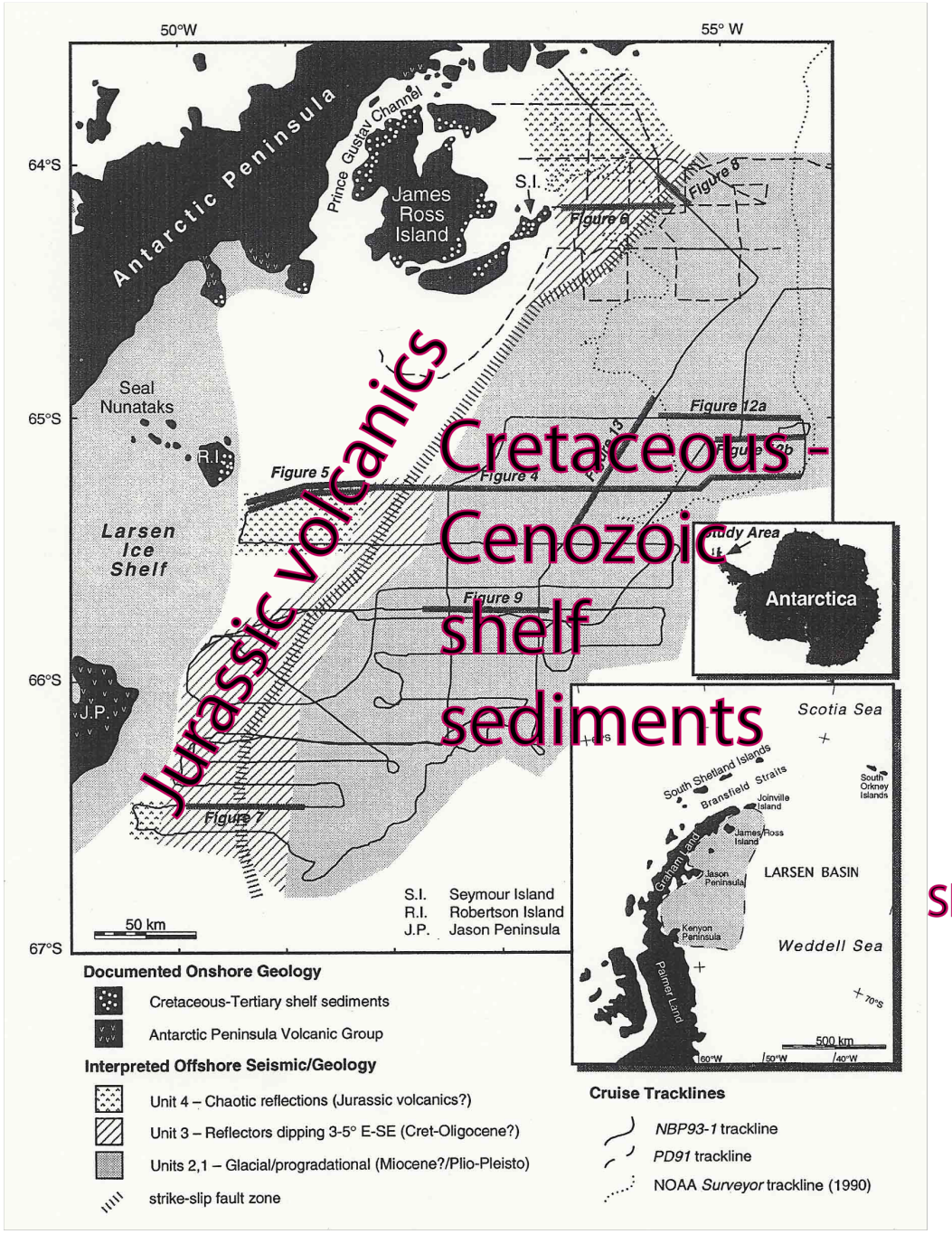


Sloan et al (1995)



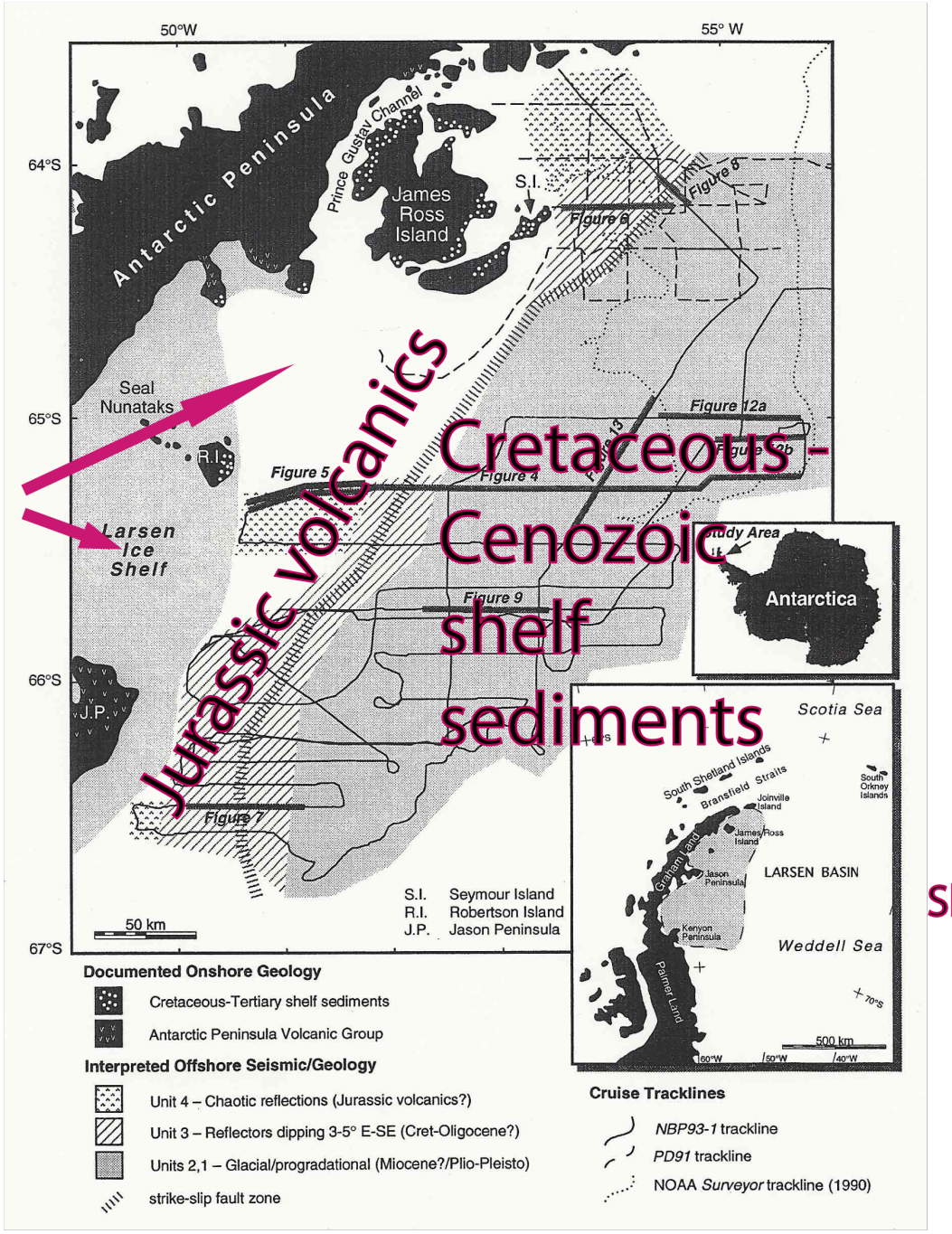
Cretaceous - Cenozoic shelf sediments

Sloan et al (1995)



Sloan et al (1995)

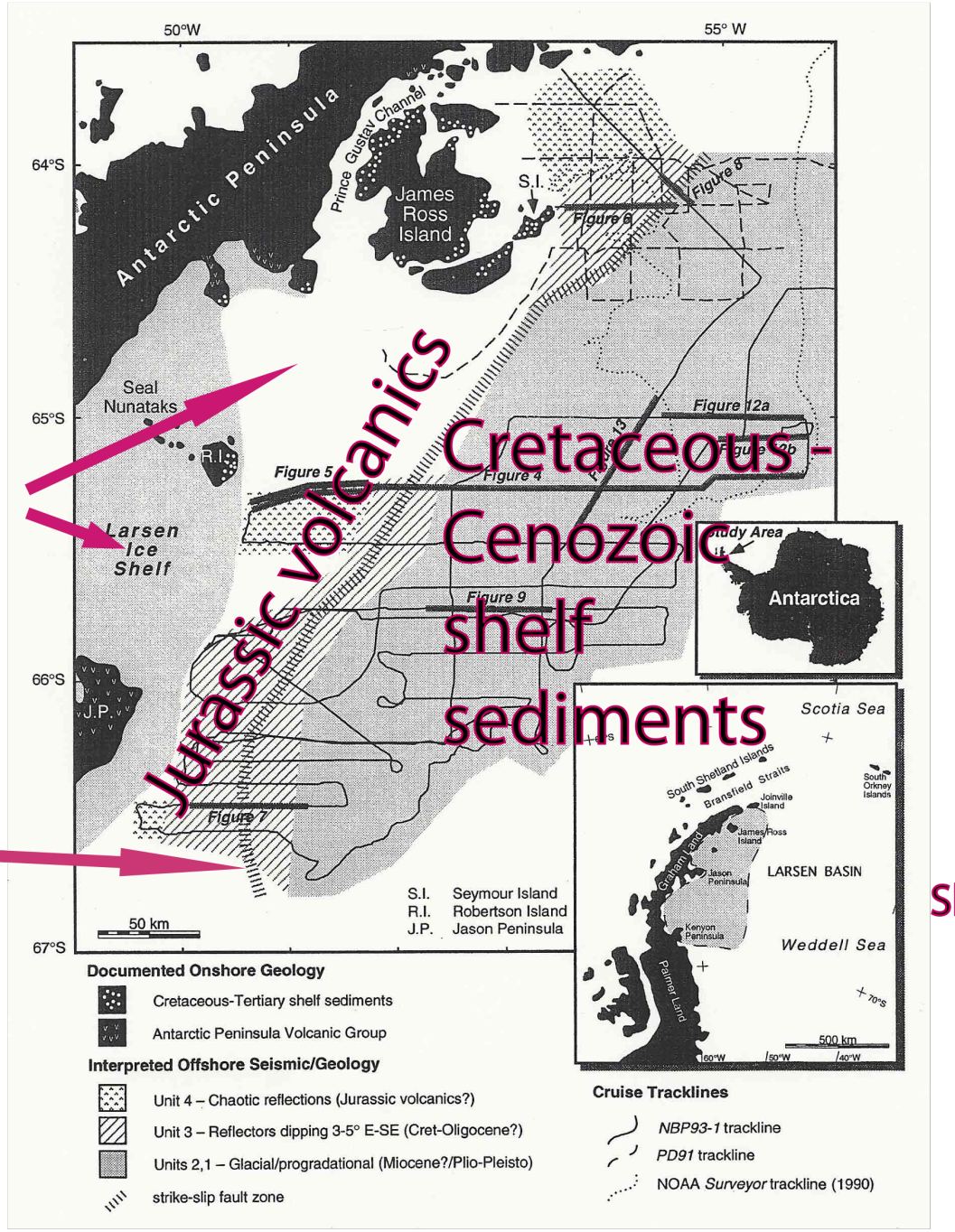
Paleozoic metaseds



Sloan et al (1995)

Paleozoic metaseds

Fault



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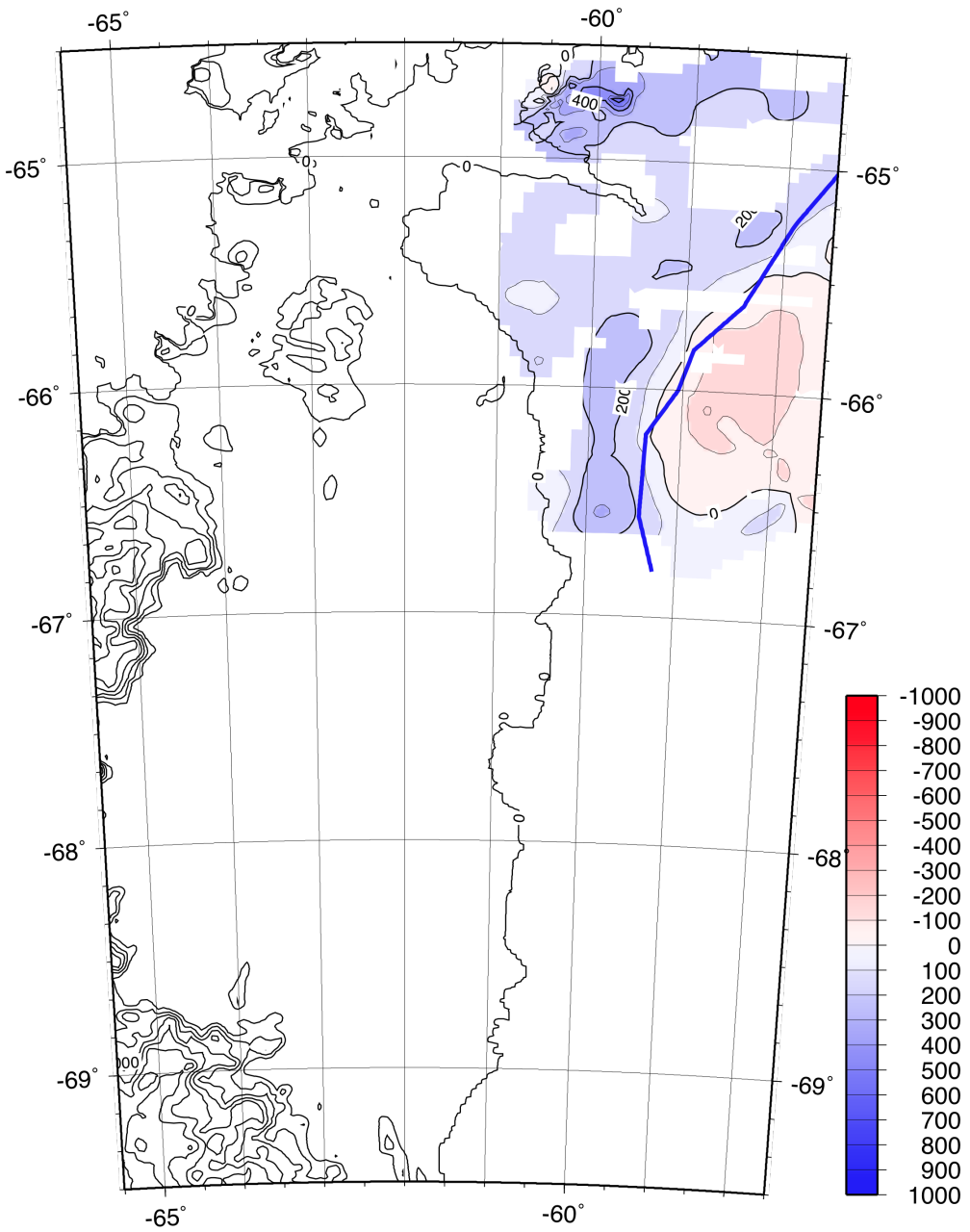
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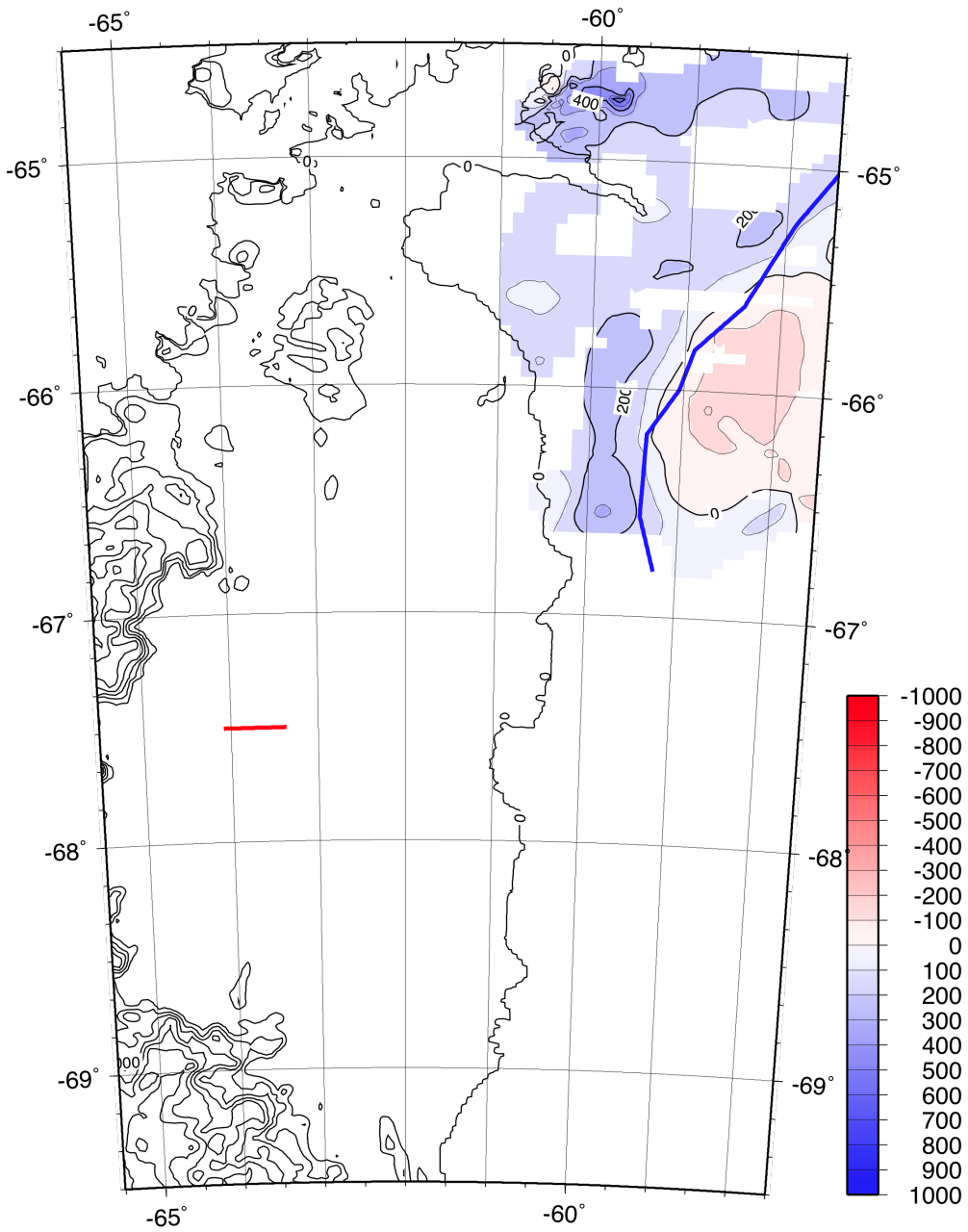
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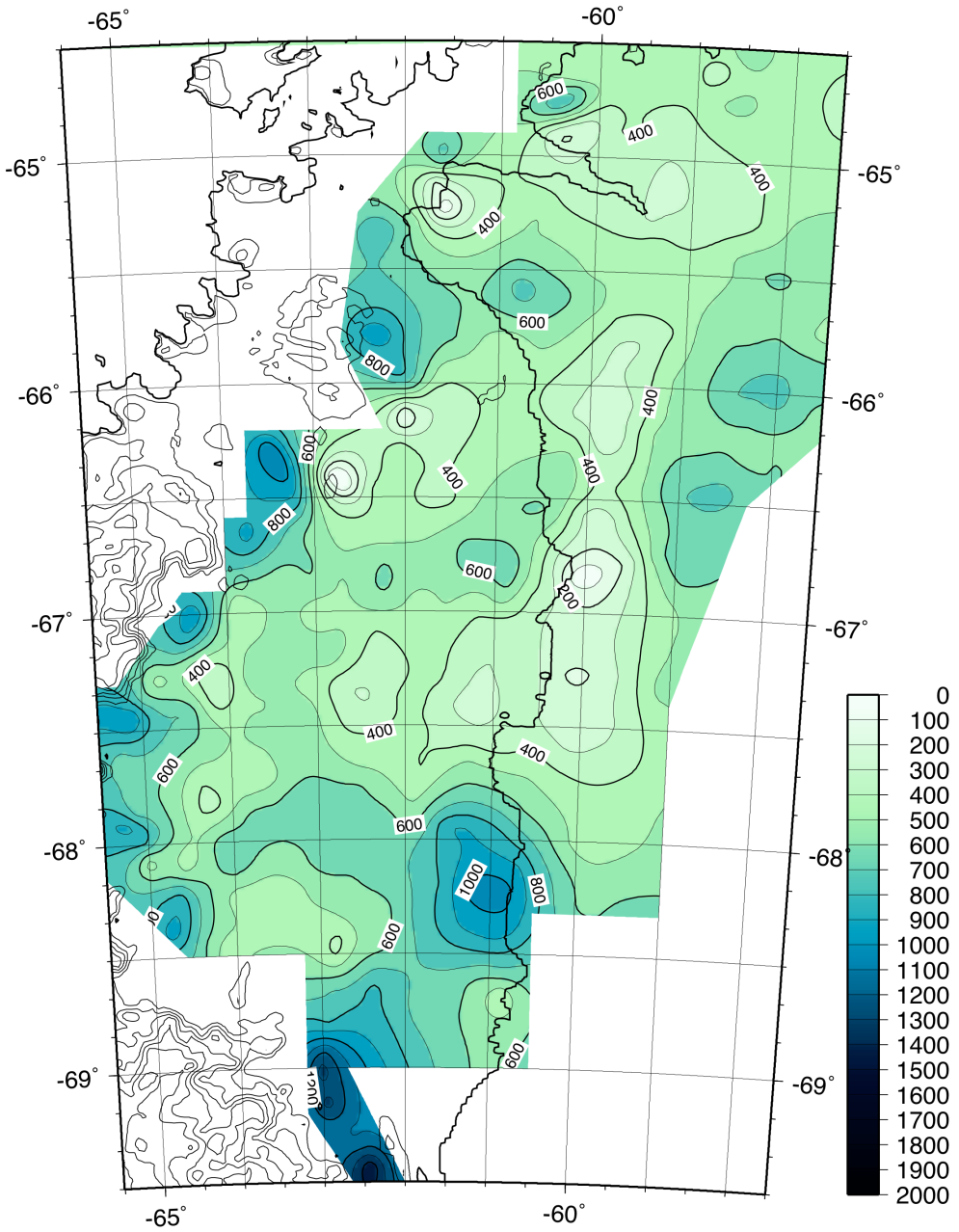
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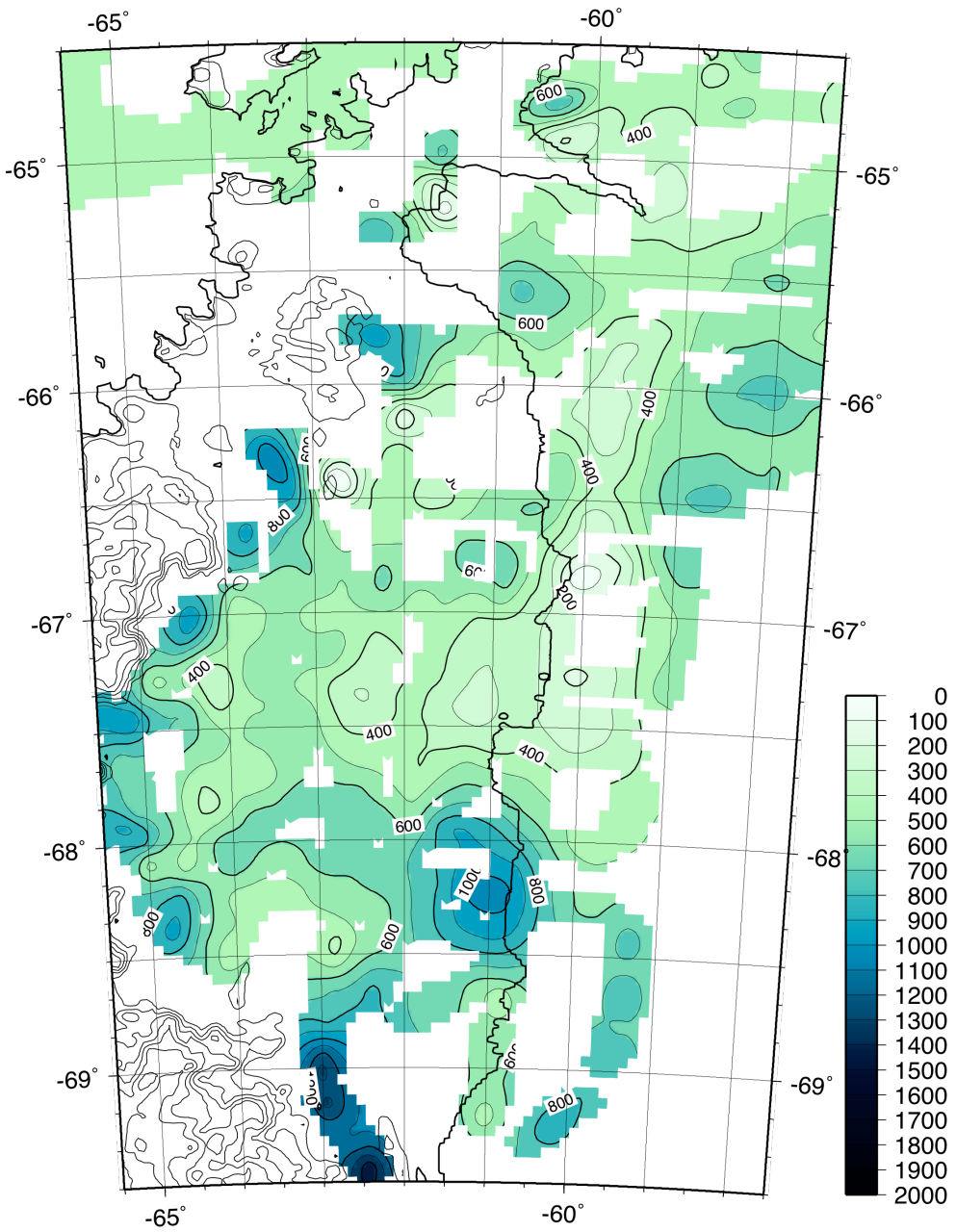
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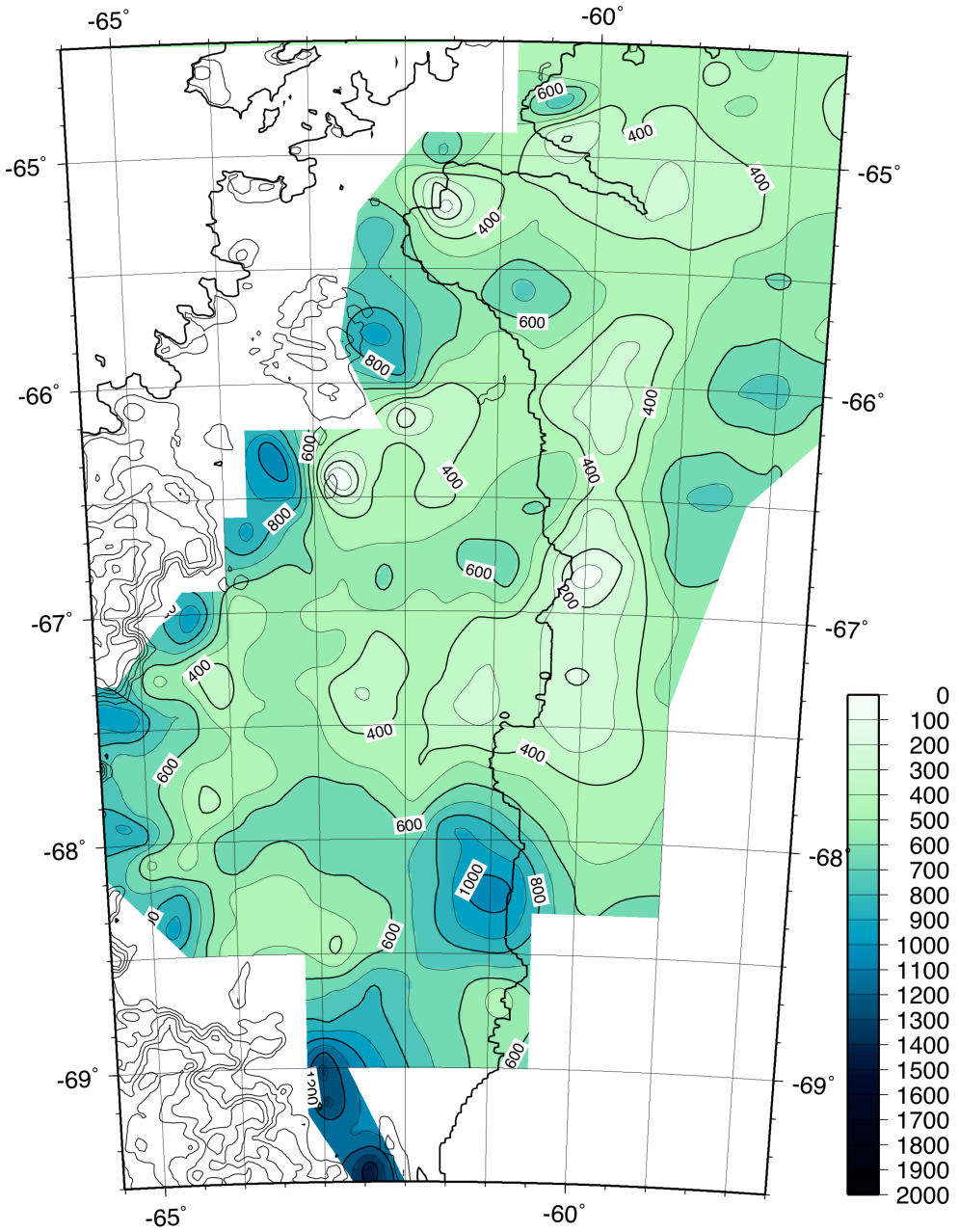
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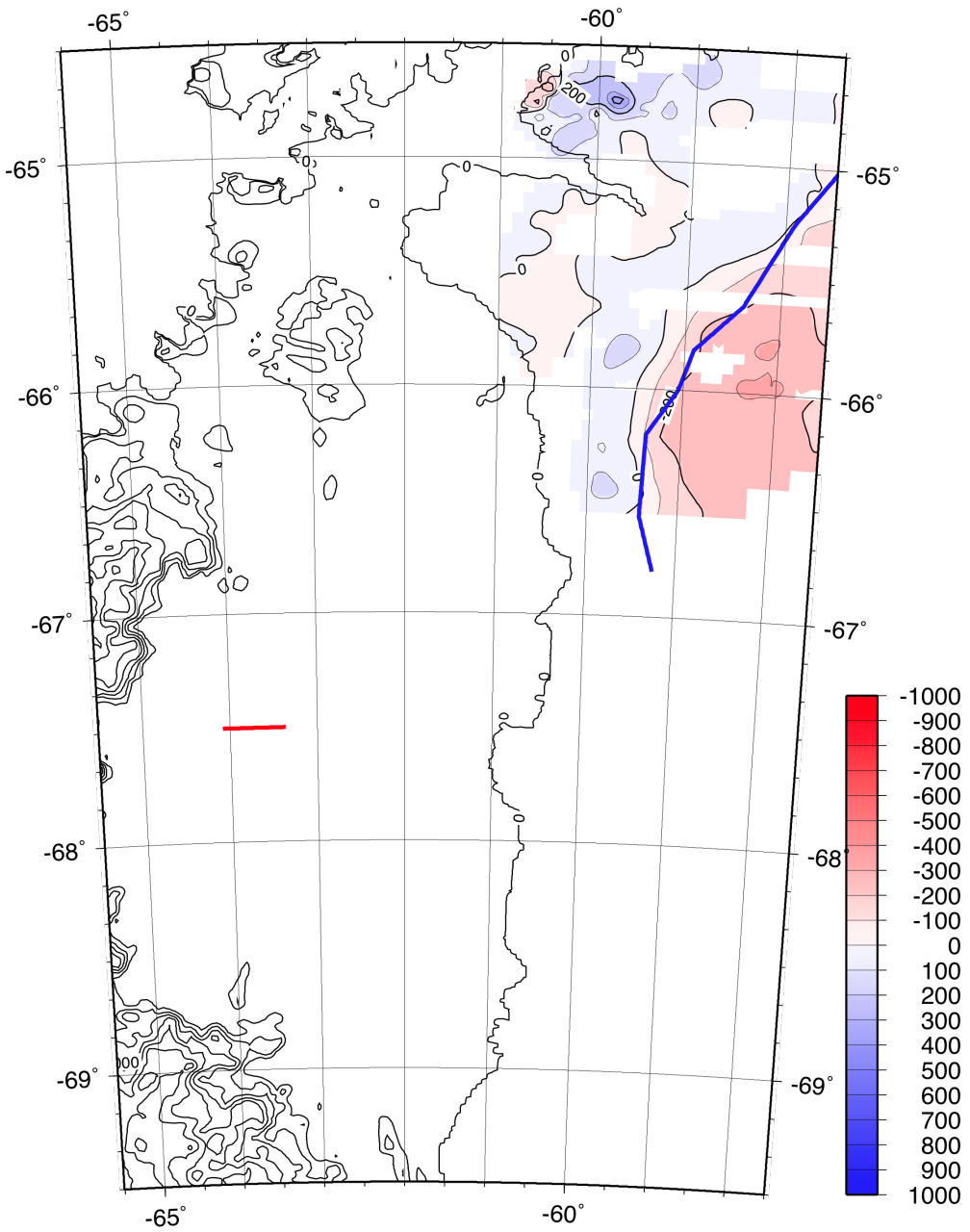
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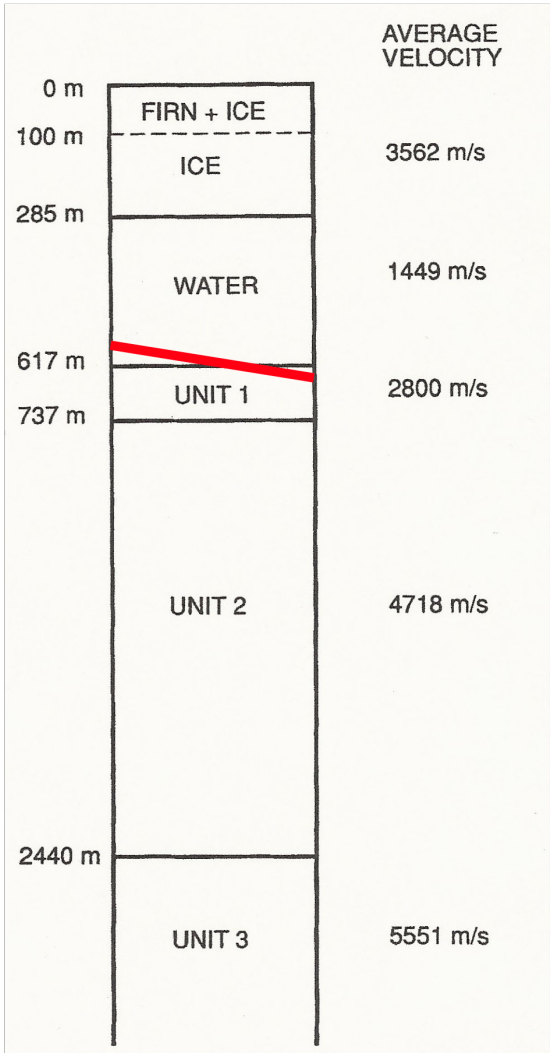
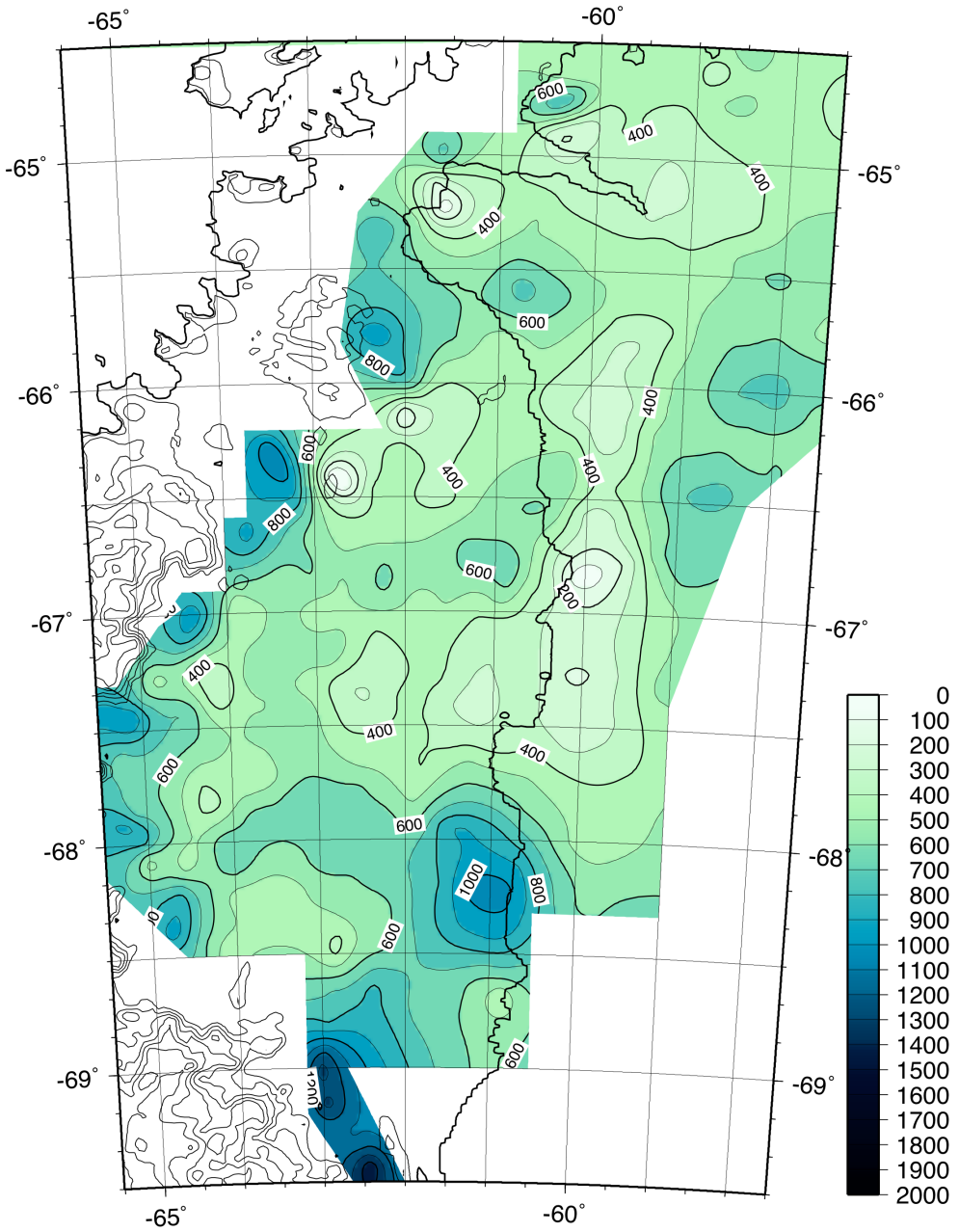


Fig. 3. Velocity model derived from the refraction data. The seismic velocity in the near-surface of the ice shelf was determined from shallow refraction data. The seismic velocity in the ice shelf and the sub-seabed velocities were determined from the expanding spread data. The expanding spread record suggests that the 5.551 km s^{-1} layer (Unit 3) extends to 7.8 km depth.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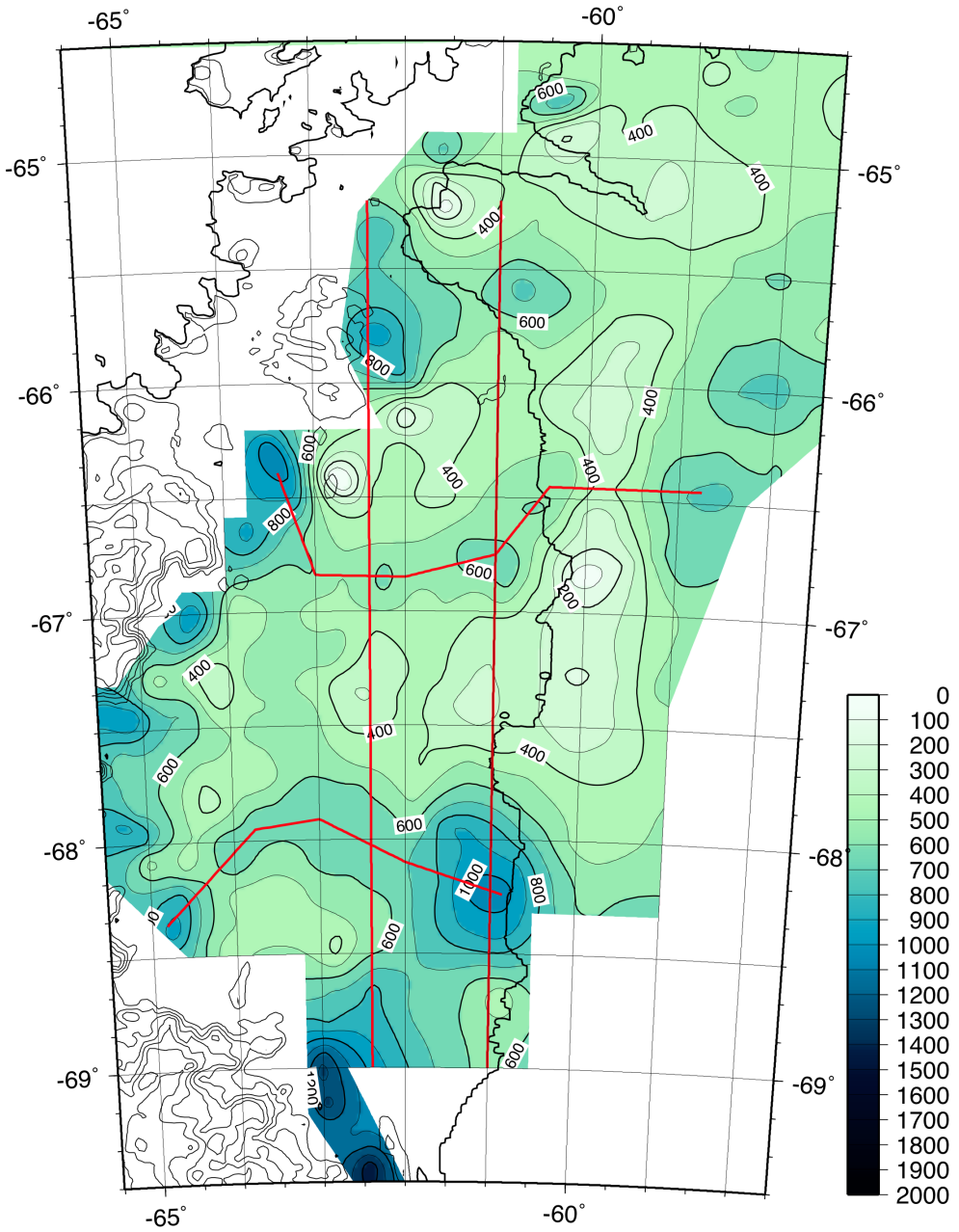
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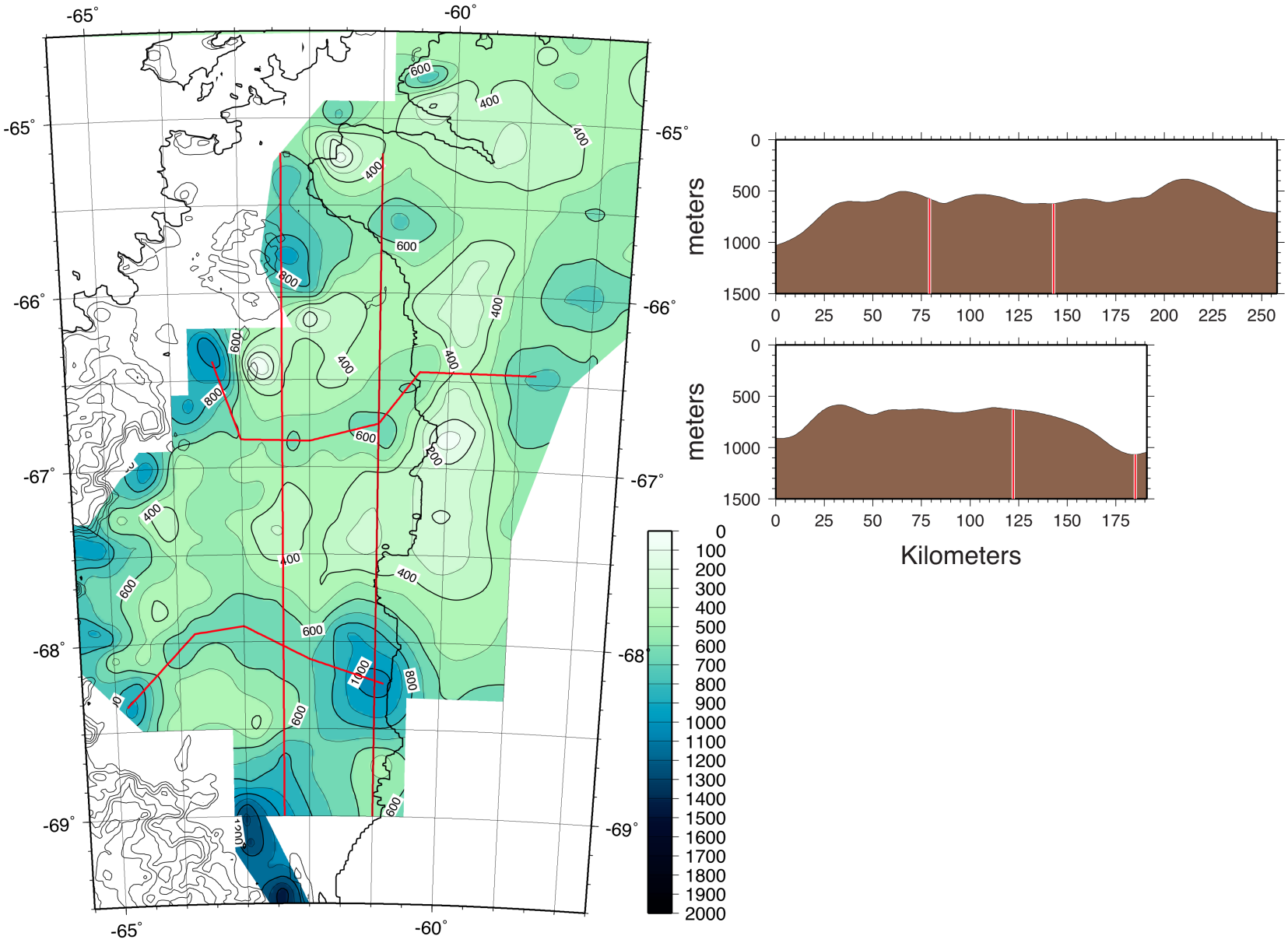
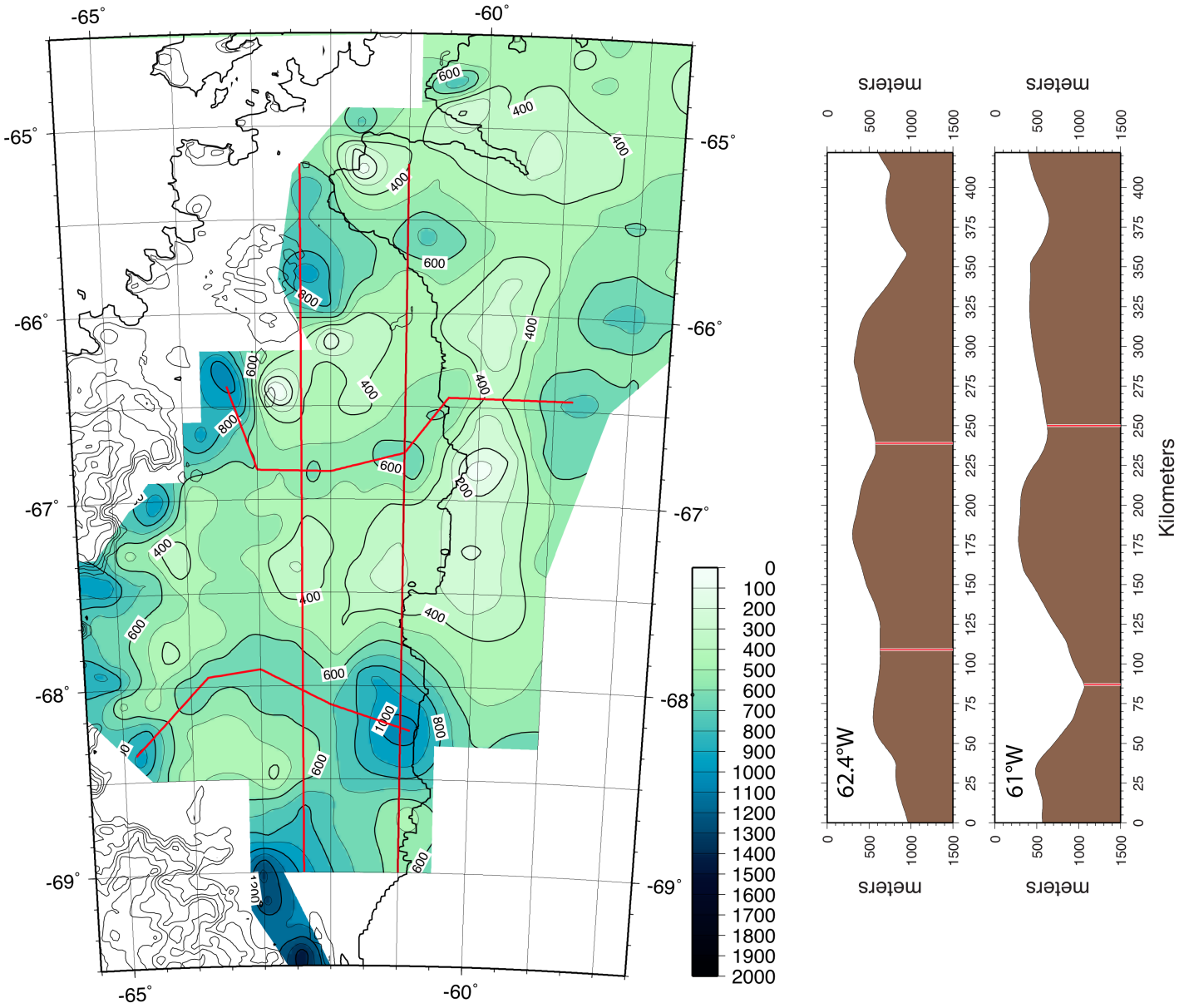
East-West Profiles



North-South Profiles



Outlet Glaciers

- Similar techniques, but more complications than at ice shelves
- Kirsty Tinto will discuss her modeling results from Thwaites Glacier at “Open-Mike” session tomorrow.

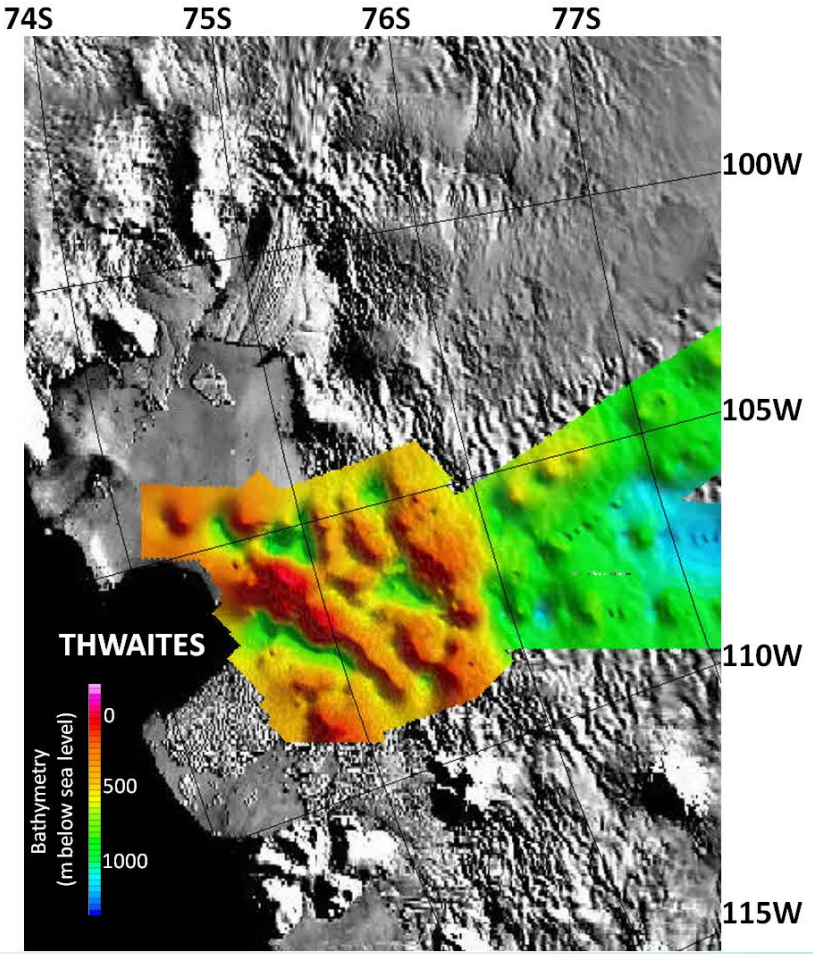


Figure from Kirsty Tinto

Sub-Ice Bed Relief

Lessons learned

- Geology matters
- Good surface elevation data matters
- Most efficient technique is inversion combined with forward modeling

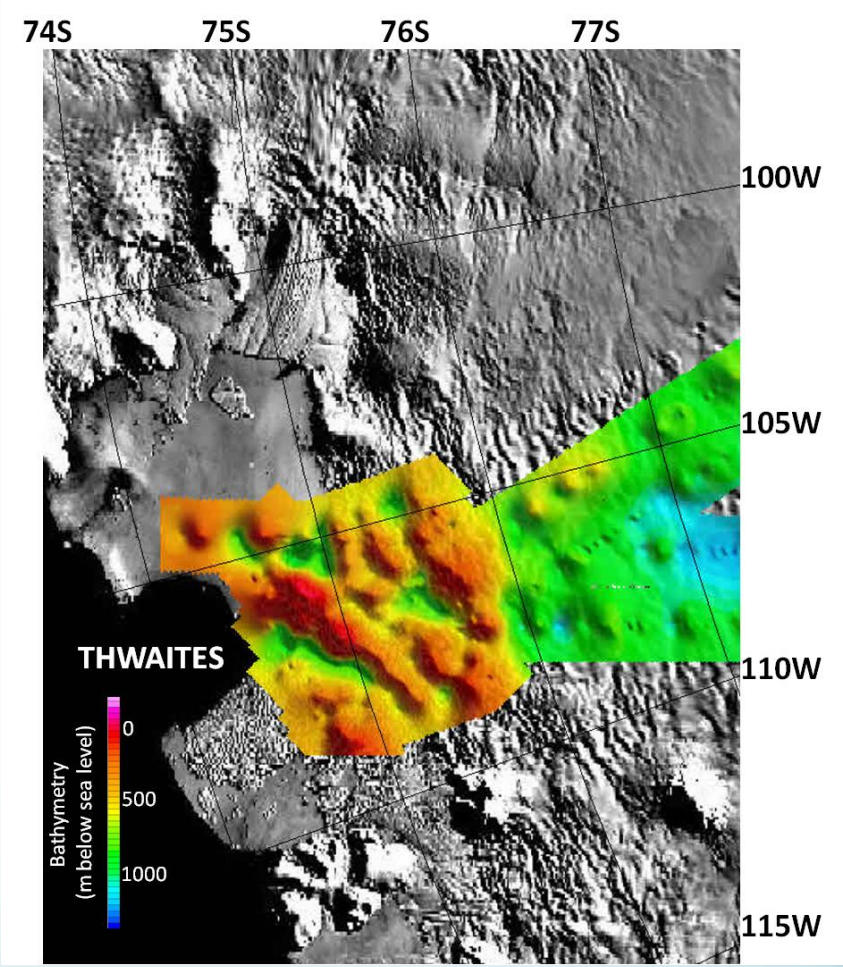


Figure from Kirsty Tinto